DAS/In-Building Wireless Training..the Last RF Frontier

DASpedia West Training

UC Irvine Campus

Soyola Baasan & Team

January 11th 2016

Welcome to our EMR Presentation

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Systems Applications Manager

EMR Corporation

Phoenix, AZ

Ask Questions Throughout the Presentation...don't be Bashful

B

Hire a Pro…

Do you know Red Adair?

- **In 1959, he formed Red Adair Company, Inc. which provided services to control oil well fires and blowouts.**
- **His established modern-day effective Wild Well Control techniques**.
- In comparison, EMR Corp. is well known for "Fire Fighting" with our RF Peripherals Solutions.- ***Site Mgt, Capacity, In-Building Coverage, Monitoring; Interference Mitigation***

TAKEAWAY- If you think it's expensive to hire a professional to do the job, wait till you hire an amateur!

Thoughts to Ponder….

- **The Only Decision a Business Makes is to Spend Money (wisely)…** **David Carey, former Economics Professor, University of Pennsylvania, Wharton School of Business**

- **We *Embrace Change* when we're Attempting to Control a Situation or GROW and Current Resources or Systems:**
  1. ***Put Lives and Well Being are at Risk***
  2. ***Lack responsiveness* or can't meet the need with Products, Solutions or Systems**
  3. **You Aren't Technically, Operationally or Financially *COMPETITIVE***
  4. **Or when you're in Trouble**

In-Building Wireless...
The Last RF Frontier

Many cities and counties in USA/NA are mandating In-Building Coverage for First Responders- Fire, Poiice, EMS, Dog Catcher.

- Certificates of Occupancy for new buildings may be made contingent on satisfactory (-85 to -95 dBm signal levels) signal levels
- Safety, business efficiency and productivity can be realized.
- Better utilization of personnel, assets and resources; two-way radios and pagers can work where they couldn't without In-Building Coverage Enhancement
- Outside coverage is extended inside seamlessly and without user involvement/thought
- ***Can be a Profit Center/Income Source...NEW GROWTH Market.***

Class A Booster Amplifier

Class A- Channelized, Selective-

- Useful for High RF or some Urban Environments
- Channelized BDAs make sense in the competitive environment of cell phones.
- Channelization is typically *not needed* in the majority of public safety applications.
- Police and Fire can save some money which can be spent on other critical infrastructure requirements.

Class A Booster Amplifier

MORE Tech/Optns/Finance Considerations

- **Digital Compatible BUT MAY INTRODUCE "FILTER GROUP DELAY" WHICH POTENTIALLY ADDS NOISE & COMPROMISES PERFORMANCE**
- **Generally available in UHF, 700/800/900 MHz bands; not VHF**
- **Can use of 75 kHz Selective & Crystal Filters for Channelization**
- ***You Must Design for Nearby Jurisdictions; agencies that may be Needed in Mutual Aid/Multiple Alarm/Regional Amplification Requirements. Ex: 11 Counties Surrounding Bay Area, CA***
- ***What happens if "First Responder" arrives at an incident and the Channelized BDA isn't programmed for ALL his channels...could be MAJOR SAFETY ISSUE!***
- **Typically More Complicated to Design, Deploy; *Record Keep* & Maintain**
- **Higher Cost**

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Class B Booster Amplifier

- Class B- Non-channelized; useful for Lower RF Noise Suburban, Rural and Urban Environments
- Digital Compatible
- Generally available in VHF, UHF, 700/800/900 MHz bands
- Easy to Design for Nearby Jurisdictions; agencies that may be Needed in Mutual Aid/Multiple Alarm/Regional Amplification Requirements
- Flexible and Adaptable to Changing RF Needs
- Class B- Broad Band Filtered; not Channelized but Controlled by the Selectivity of the Filters- 75 Khz BW
- Less Complicated
- Lower Cost

In-Building Systems Design Template--- Fill it out---we will take it from there...

EMR corp. Celebrating 35 Years Est. 1980

Uni- and Bi-Directional Signal Enhancement Systems

Received on: _____ Time : _____ Via : _____ Status: _____ Date: _____

Rick Phillips, Tech. Support, 800-796-2875 Alan Leffler, National Sales Manager, 602-614-6716 Bruce Wallace, Regional Sales Manager, 623-980-2069

Company : _____

Contact(s): _____

Address : _____

City / State /ZIP: _____

Phone(s) : _____

Email (s) : _____ @ _____

Site Designation: _____

EMR Global Quote #: _____

EMR Global ID: _____

Customer Ref.: _____

System Block: _____ .vsd

Int'l Destination: __ -- _____

1)

	Base to Donor Down-Link (DL) (Base Station to Portables – Repeater Tx)	BW	Donor to Base Up-Link (UL) (Portables to Base Station – Repeater Rx)	BW	Stop Band
More Frequencies see Page 2	1)		1)		0.0000
	2)		2)		0.0000

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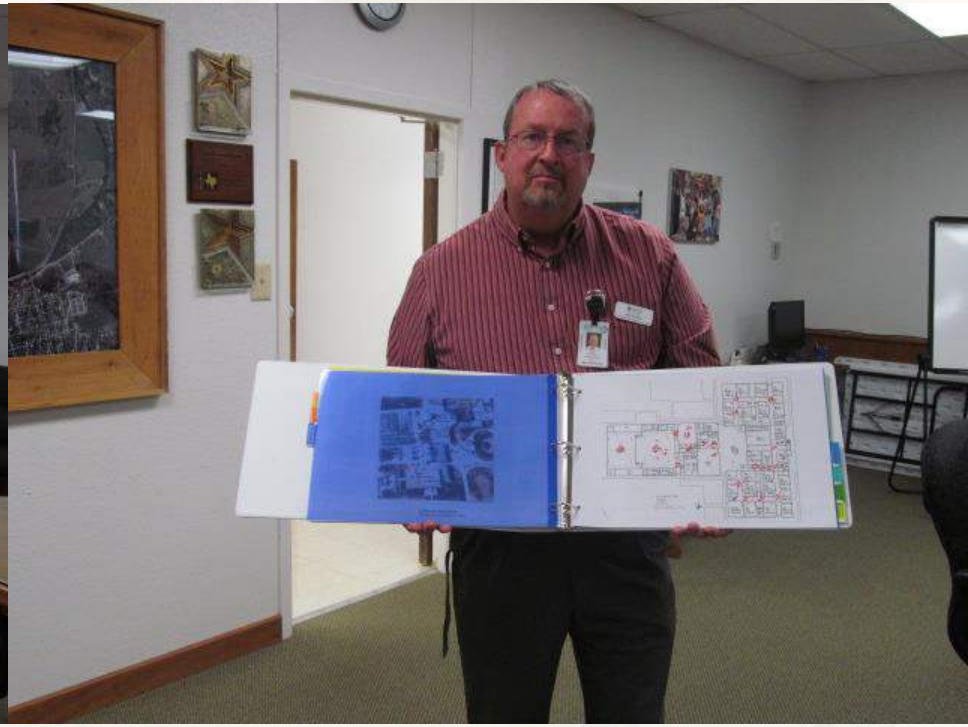
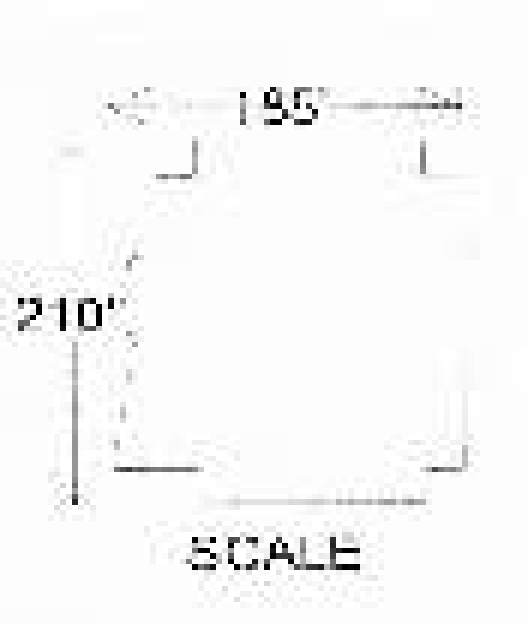
Providing Site Details are Essential...

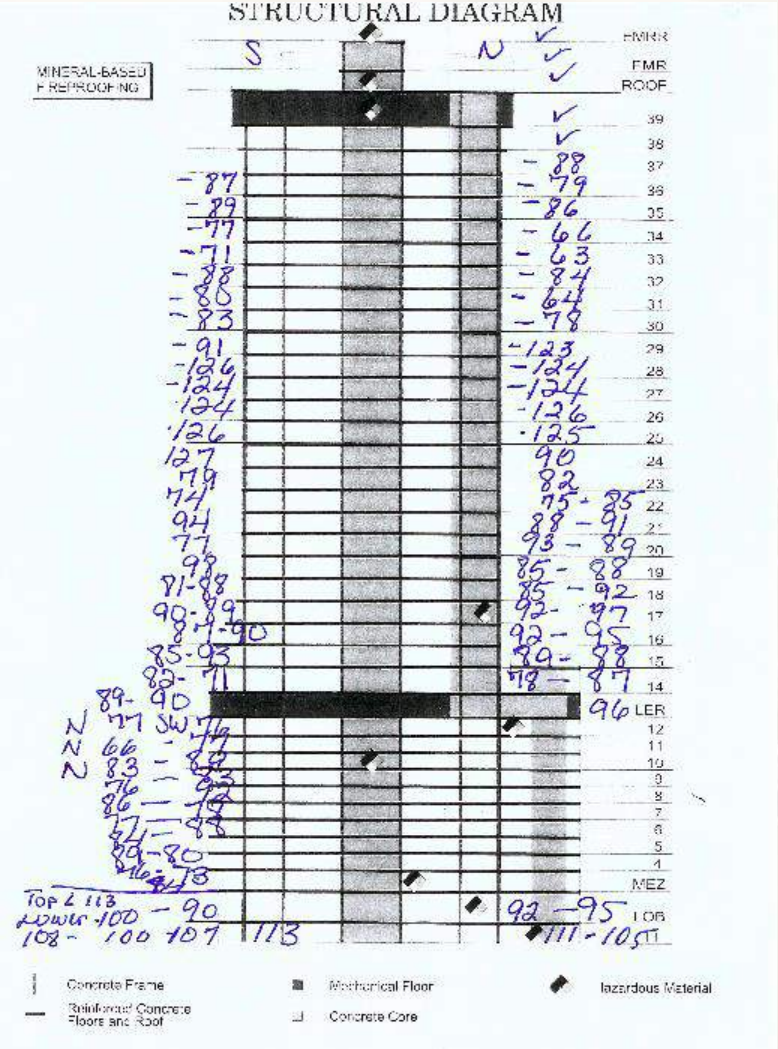
Wes Strahan of City of Burnet, TX
KNOWS ALL School SIGNAL LEVELS, has Meticulous Documentation/Plans and where In-Building Enhancement is Needed. This is VERY HELPFUL for Designing Correct Solution!



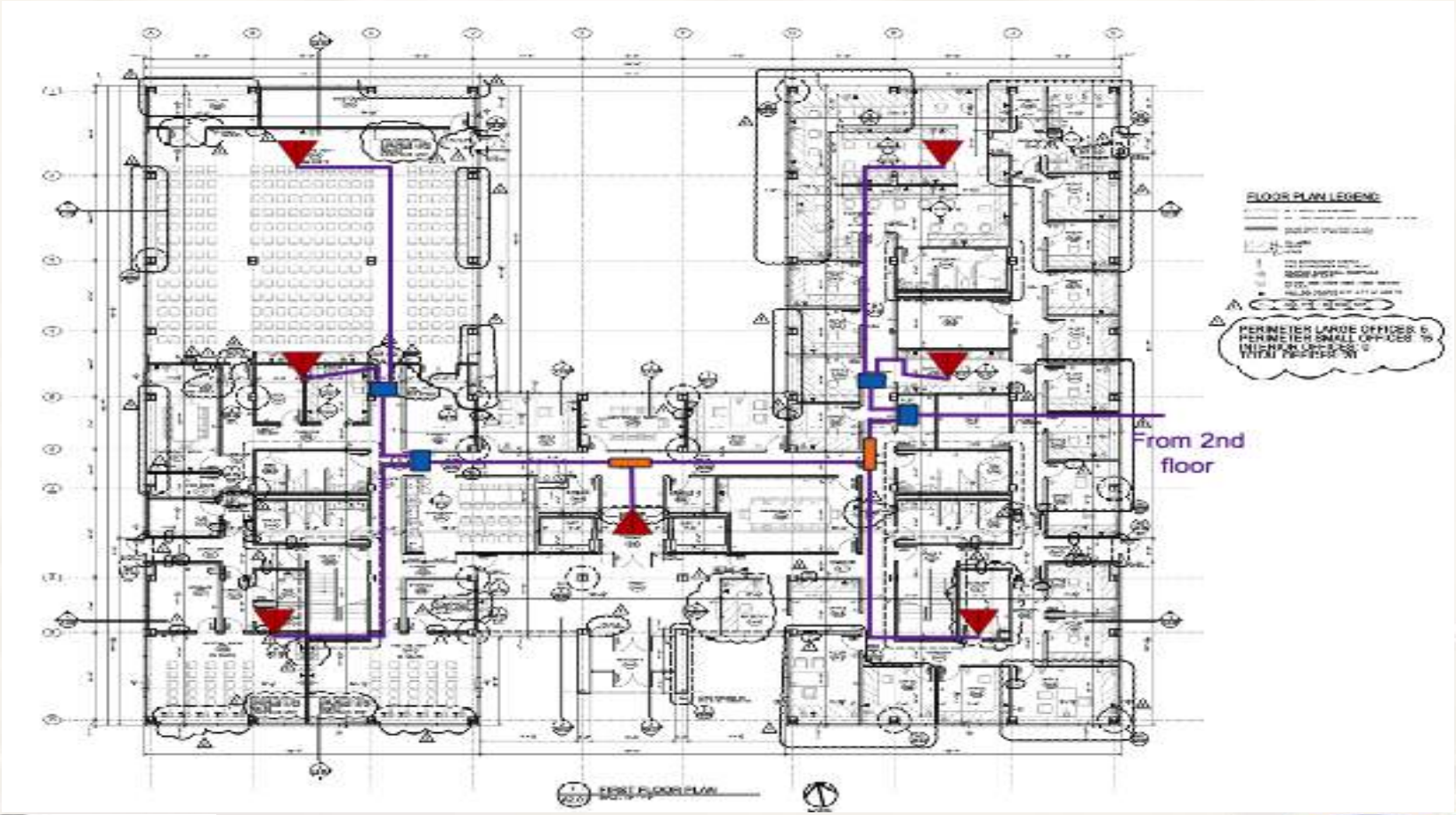
Knowing Drawing Scale, Details & TeleComm Closets is Important...



Customer Furnished Signal Readings...



DAS Systems Design Example...



Base Station/Repeater Co-Location...

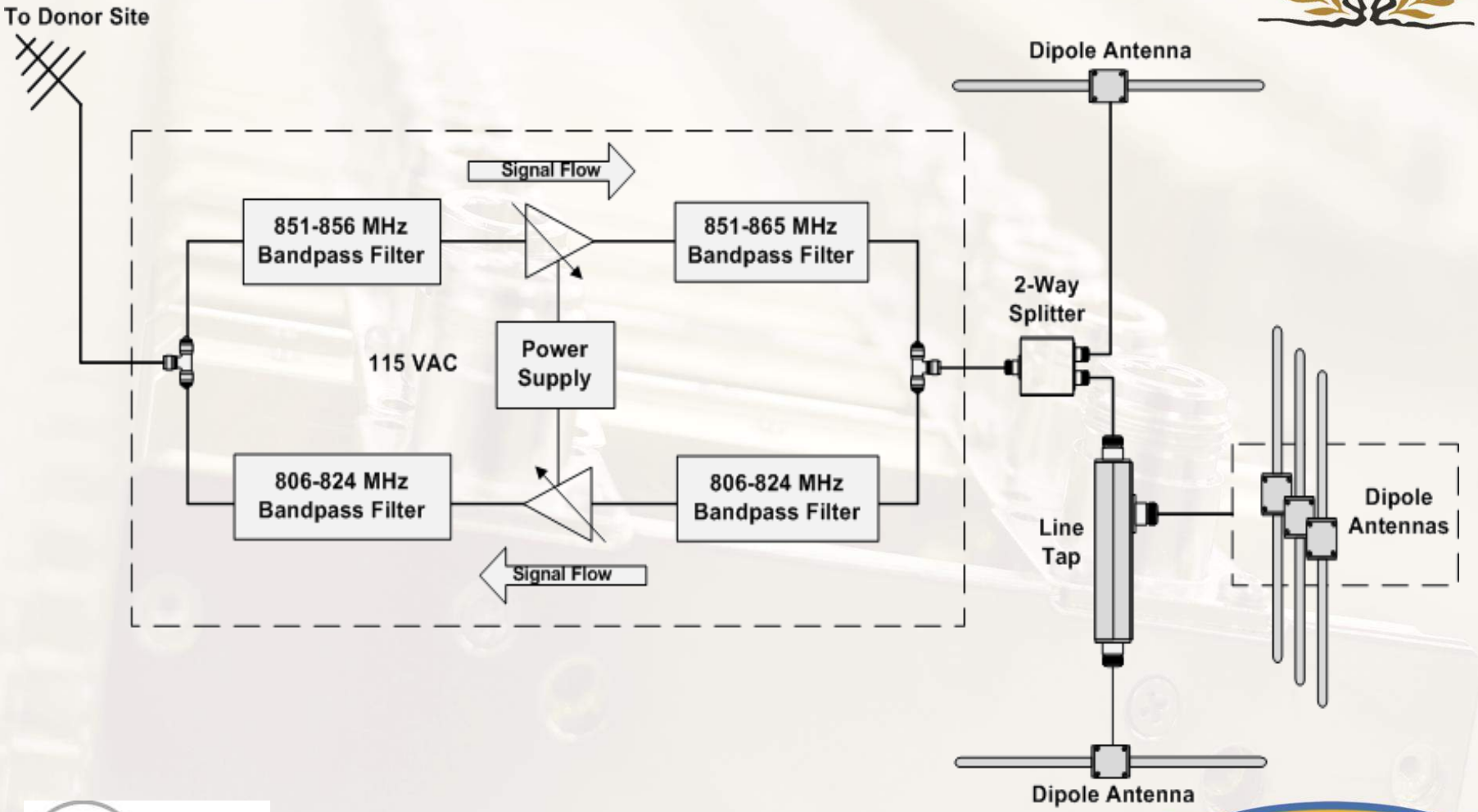
The **SYS Compact Combining Solutions** for most LMR, PMR, Public Safety applications where high insertion loss is not a major system detriment.

Ideal for Base Station or Repeater Co-Location as a **"Front-End" to an In-Building/DAS System. ONE ANTENNA OUTPUT PORT**

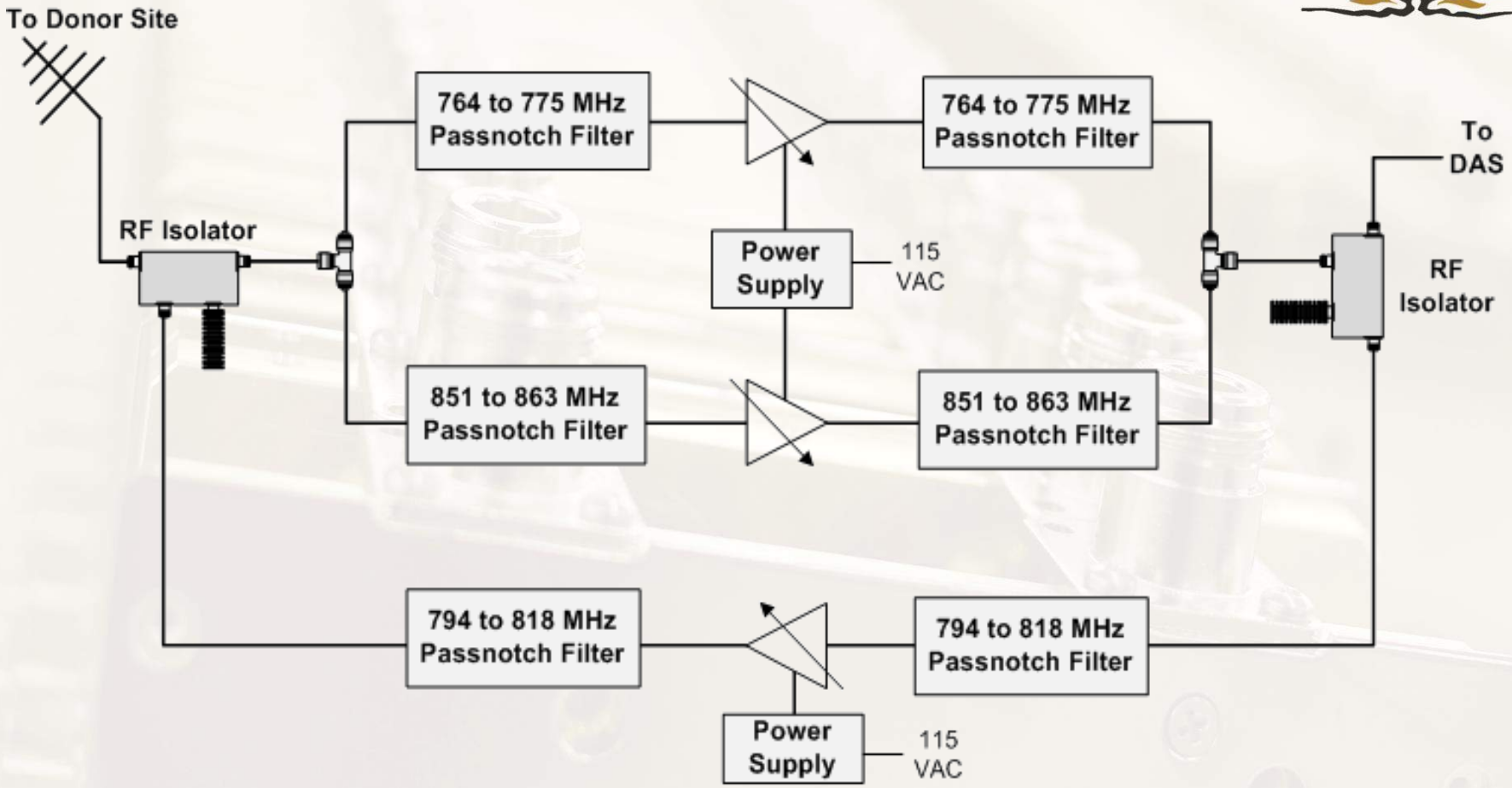
These offering the most practical approach to full duplex combining in mobile and base station applications. These are single antenna systems. Each model includes transmitter combiner, receiver multicoupler and antenna duplexer.

The systems are delivered ready for operation with no on-site tuning or adjustment needed. Loss figures are nominal. Losses and gains per individual channel can vary over filter bandwidth.

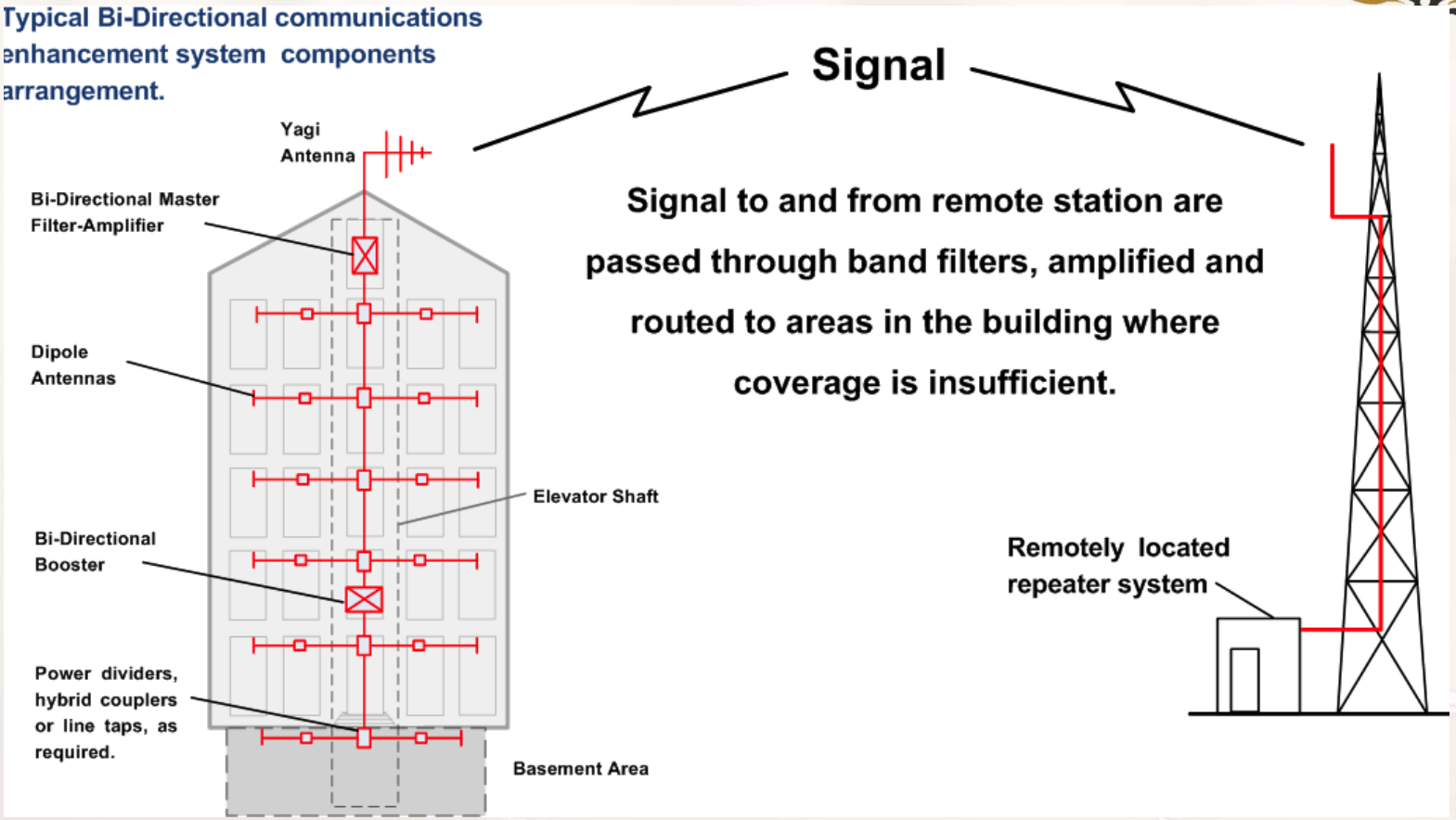
800 MHz Booster System Schematic



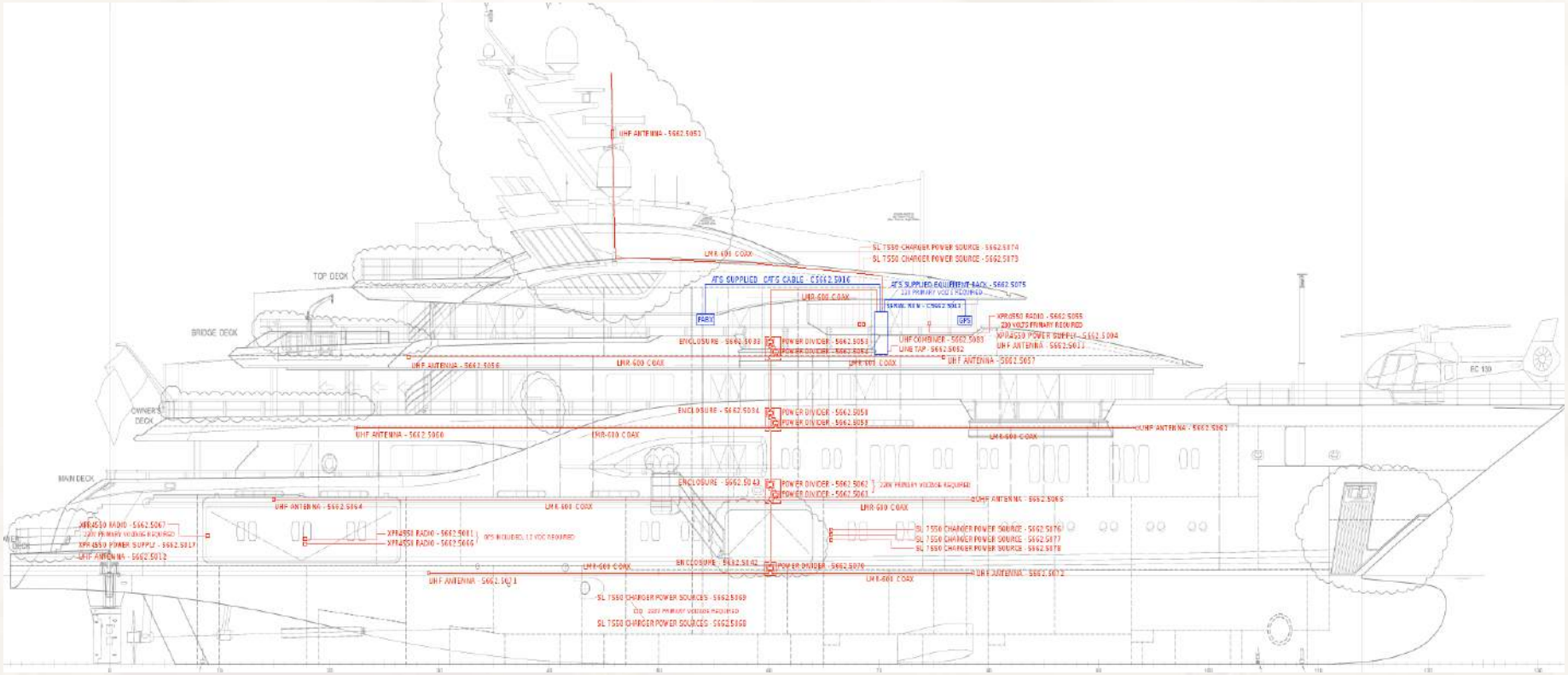
700/800 MHz Booster Schematic



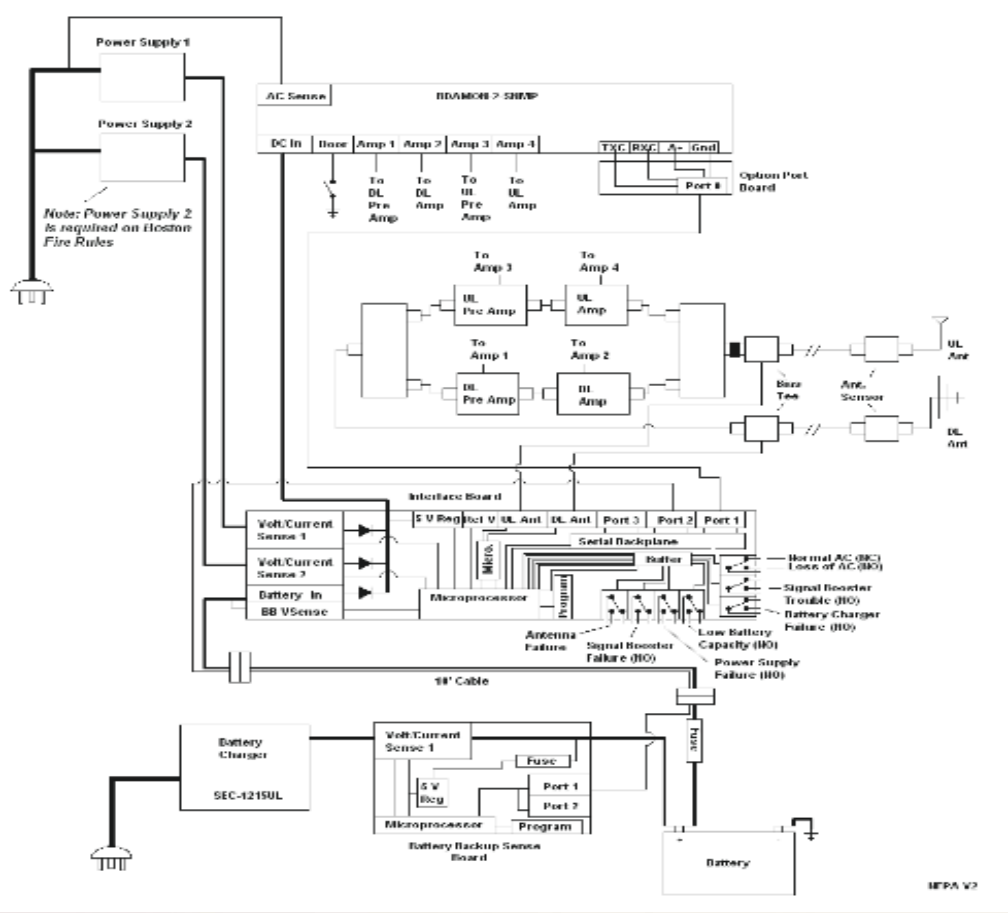
DAS System Diagram using CAI



DAS Schematic Layout for Shipboard Communications...Applications are Many!



NFPA Monitoring/Battery Back-up Schematic...



EMR Corp. BDA & UDA Options

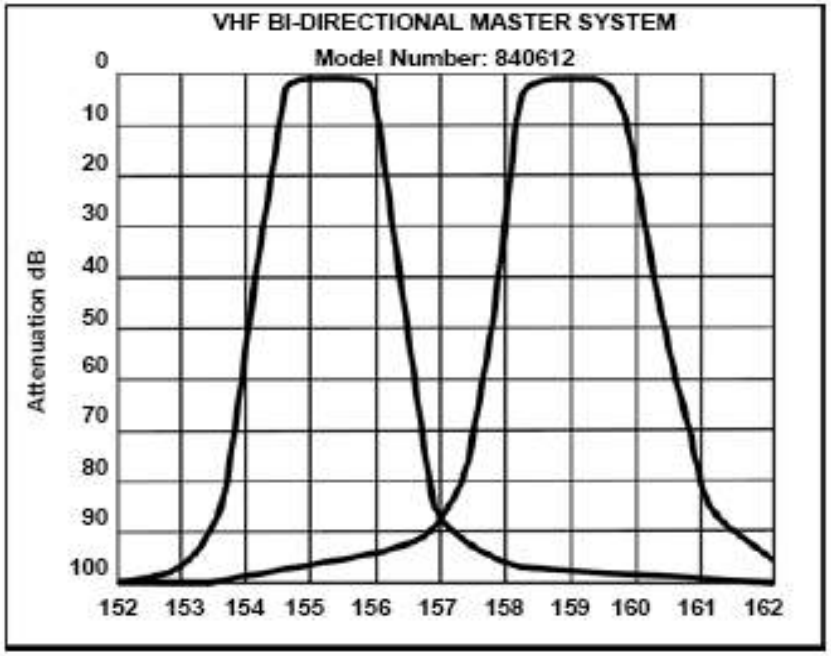
- **IP Based Monitoring** (BDAMON-2 or NFPA Compliant)
- **Customized Case Paint** (shown in RED)
- **Uninterrupted Power Supply - UPS** (Battery backup)
- **+12 or 24 hour run time battery** (Configured in a separate NEMA box)
- **Rack Mounting Available**
- All options are quoted on a custom basis

Customized Engineering-

SELECTIVE FILTERING/CRYSTAL

FILTERS ARE KEY

<u>Especially</u> for Multi CH/Band Applications



NFPA Alarm Monitor Interface...

There are 7 alarm relays available, these will supply contact closure (Supervisory Signal) to the fire alarm panel for the following alarms:

(1) AC Power Failure
(2) Signal Booster Failure
(3) Battery Charger Failure
(4) Low-battery capacity
(5) Power Supply Failure
(6) Antenna Malfunction
(7) Signal Booster Trouble

Note: Signal Booster trouble (any alarm) closes on any alarm except the door alarm.

NFPA Alarm Monitor Interface Illustration...

Amplifiers

…know what you're getting...

- In a BDA system by stating ONLY amplifier gain you're kept from knowing what actual system gain is including...filter losses, attenuators, duplexed losses, etc.
- Quoting amplifier gain is disingenuous unless explicitly called out as amplifier gain.
- The amplifiers used in EMR Corp BDA's generally have between 60 and 75 dB of AMP Gain depending on frequency band.
- If you're quoted 80 dB gain, *is it amplifier gain or system gain?*
- **We always state system gain, after filtering...**

About Gain and Why?

EMR recommends 15 dB of filtering *above* amplifier gain

- Increased gain increases potential for systems' oscillation.
- Higher gain = greater design, product & applications...complexities
- Whatever gain exists in the amplifier, the filters need a ***desired 15 dB more attenuation than the gain of the amplifier.***

About RF Interference

- Interference is always present in the increasingly RF saturated world.
- Non-linear joints, dissimilar metals, rusting; even chain link fences can cause interference and wreak havoc on systems coverage and performance.
- And, recently revealed...LED Light Bulbs...yes VERY **GREEN** Energy Conservative but a big generator of RF Interference particularly in the 150-174 MHz VHF Public Safety, etc. Band.

Takeaway- KNOW the building environment and frequencies to be used. It could be a very serious consideration for the safety and communications of/for "First Responders".

About RF Interference- LED's

There are plenty more of these LED type devices out there, causing interference to VHF Public Safety Radio Systems. ONE Ref: State of Missouri VHF Public Safety System

1. The established testing protocols may not be discover this RF emission problem and
2. **Unscrupulous importers/vendors may be ignoring this aspect of their products and cloak themselves in the "green-ness" of LED lighting.**
3. **THIS A BIG CONCERN!**

EMR In-Building Resources

Complete In-Building System- 2 hrs. Complimentary Design & Engineering- Part of our Bargain...

- **Comprehensive Product Line**
- **Custom Design** - ***60%+ of our Systems are Custom***
- **RF Interference Mitigation** - Factory & Field
- "**SOS**" - Site/Systems Optimization Services are available
- Customized Machine Shop- www.emrmachine.com
- **All BANDS - 5 Watt BDA's, UDA's- VHF, 220 MHz, UHF 380-512 MHz/UHF T Band; Combined 700 MHz & 800 MHz; 900 Mhz & 1.8 Ghz**

In-Building Resources (continued)

- **CRYSTAL FILTERS** - Selective and Essential for some VHF Applications
- **IP Based Monitoring** - Product and Service
- **Indoor Antennas** - Dipoles, ¼ Wave Ceiling
- **Line Taps** - 1,2 & 4 way (10 to 25 dB Coupling Factor)
- **Splitters, Combiners & Dividers**
- **Factory Integration** of EMR bidirectional systems with fiber optic back haul for LARGE CAMPUS Applications
- **5 year Warranty - Industry Leading & Unconditional Satisfaction Guarantee**

In-Building Regulation Example

Boston Fire Department Communications Section
Specification for Fire Fighter Communication Systems (Revision 16)

The Boston Fire Department has developed this specification in conjunction with the requirements of the International Building Code (2009) and the Commonwealth of Massachusetts Building Code, 8th Edition (eff. 1/7/2011).

The installation and operation of radio based fire department communication systems must comply with this document which contains the Boston Fire Department In-Building Radio Specifications.

Property owners who maintain compliance with this specification are granted permission to operate these radio amplifiers on frequencies licensed to the Boston Fire Department by the Federal Communications Commission. The failure to maintain compliance with this specification will result in the automatic withdrawal of said permissions.

The voluntary adoption of this specification must comply with all of the requirements of this specification.

Prior to the construction of a Fire Fighter Communication System, a permit must be submitted to:
Boston Fire Department Communications Section 59 Fenway
Boston, MA 02115
Fax # 617-343-3060.
Revision: 16

Perhaps Most Importantly

OB

EMR corp. Celebrating 35 Years Est. 1980

Ease of Access to Answers!

CALL 1-800-796-2875 or email-sales@emr.com

- *Doug Ferrini- VP Systems Manager*
- *Michelle Yager - Sales & Service*
- *Kim Bock - Sales & Service*
- *Rick Philips- Projects/Applications*
- *Bruce Wallace- Regional Manager*
- *Alan Leffler - Sales Manager, Americas*

TAKEAWAY- RF Antenna Solutions Experts

Visit: ***Web:*** *www.emr.com*

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Thank You !

Questions ?

Discussion ?

We are all looking forward to working with you...

Alan Leffler, N7WYE
Sales Manager, Americas

alan@emrcorp.com

Web: www.emr.com

Class B Signal Booster School & Certification

Chapter I

by Douglas B. Ferrini

VP Systems Engineering

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EMR In-Building School & Certification

Classes available for:

- **Consultants**
- **Systems Designers**
- **Integrators & Dealers**
- **Installation and Optimization**
- **Training Cost- $5000 ON-SITE Up to 10 students; Cost is $0 if Conducted at our Factory (just your labor & travel expenses)**

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BDA Broadband (Class B) Basics

- A BDA is a device used to improve portable or mobile radio communications into areas which are otherwise shaded from the fixed repeater(s)
- The separation between the repeater transmit and receive frequencies be sufficient
- Non-Heterodyne, or Broadband Repeater Amplifiers utilize linear amplifiers with Uplink (UL) and Downlink (DL) filters that restrict pass bandwidth to some specified frequency range.
- No frequency conversion processes are involved in the BDA's operation. Filter pass bandwidth can range from 75 KHz to several MHz.

BDA Components

Non-Heterodyne two way repeater amplifier system flow diagram (Figure 1).

Broadband repeater amplifiers typically consist of the following basic elements:

- Linear amplifiers which provide the RF gain and output power
- Power control or Gain control circuitry
- UL and DL filters
- Power supply
- A rack, cabinet, or enclosure

In-Building Coverage Applications

- Office buildings,
- schools (kindergarten through college campuses),
- casinos,
- jails, court houses, police stations,
- hospitals,
- In effect any large building is a candidate especially those *having floors which are below grade.*

water treatment facilities,

manufacturing facilities,

shopping malls,

parking structures,

power plants (nuclear, coal), hotels,

apartments, condos, and golf courses.

EMR Corp. In-Building School Overview...

General Topics-

Bi-Directional BDA Broad Band
Impact of Low Level Power
Donor Antennas
DAS Concepts &
Shared Infrastructures
Details to Design BDA
Details to Design DAS
Commissioning
RF Coverage Confirmation
Maintenance

- Two Way Repeater Detail
- Mandated Battery Back-up
- Mandated Alarm & Monitoring
- Real World Applications
- SB Class Definitions
- Requirements for Class B
- Effects of Multiple CH
- Self Test Questions
- Certification

Figure 2 Non-Hetrodyne BDA

VHF BDA in Standard Gray Enclosure

BDA Options

Typical options include

- Battery backup
  - 12 Hour
  - 24 Hour
- Alarm and monitoring
  - Modem
  - SNMP
  - NFPA72
- Red Paint (no cost std. option)

Amplifier Linearity

- Understanding the difference between power and gain in a BDA can be difficult.
- While a BDA may be capable of 5 watts out of the amplifier the actual power output is a function of:
  - the input signal level,
  - the number of carriers,
  - the amplifiers power control limits,
  - the PA input and output filter losses,
  - and the gain of the amplifier.

Amplifier Details

- In most BDA applications it is rare for the DL or UL signals to drive the PA into power control.
- -50 dBm of signal to the donor antenna from the repeaters is about average.
- With a 65 dB gain BDA, a single RF carrier would exit the BDA system at +15 dBm; which is far below the 5 watts that the PA is capable.

Systems Gain/Control

- Amplifier gain requirements will vary from one application to another.
- The BDA gain is set fixed at the factory
- Its determined by the system design or as indicated by the customer.
- The *"Systems Gain"* listed in the BDA specifications represents the *sum of all the individual stage gains in each branch, minus the input and output filter losses.*

Filters

- In ***one-way*** (Unidirectional (UDA)) systems, input filters reject undesired signals in order to minimize the potential for interference and minimize the spectrum amplified by the PA.
- UDA output filters attenuate spurious out-of-band amplifier noise.
- In ***two-way*** BDA systems, the input and output filters in adjacent amplifier branches provide sufficient selectivity, attenuation, and cross-over depth in order to insure stability between the UL and DL amplifiers.

Complex BDA Systems

- Often, the frequencies that are to be supported by the BDA require more than two branches.
- Stable operation of the amplifiers can only be achieved with filter designs that provide sufficient isolation between all possible branch pairs.
- In this filter scheme it may help to visualize the BDA as being a combiner & multicoupler which are then duplexed to a common port.
- This is often used in VHF and UHF BDA's because of the repeater frequencies that are required to be supported *having interleaved repeater TX and RX frequencies.*

Enclosures

- Standard BDA's are housed in painted steel enclosures rated to NEMA 4X standards.
- Colors- **GRAY** or **RED** (N/C option)
- Some BDA's are so large that housing them in such enclosures can be cost prohibitive.
- In such cases BDA's are configured for 19" EIA rack mount and housed in either a cabinet or open relay rack..

Alarm & Monitoring

- **SNMP - NFPA72 compliant**

- The Relay Output Port (J11) is a DB25 Male connector typically located on the bottom right panel of the BDA.
- A label of the pin-outs is also located inside of the door of the BDA.
- A DB25 Female connector (with hood hardware) is supplied with the unit for the Install Technician to connect to the Alarm Panel..

NFPA Alarm Conditions

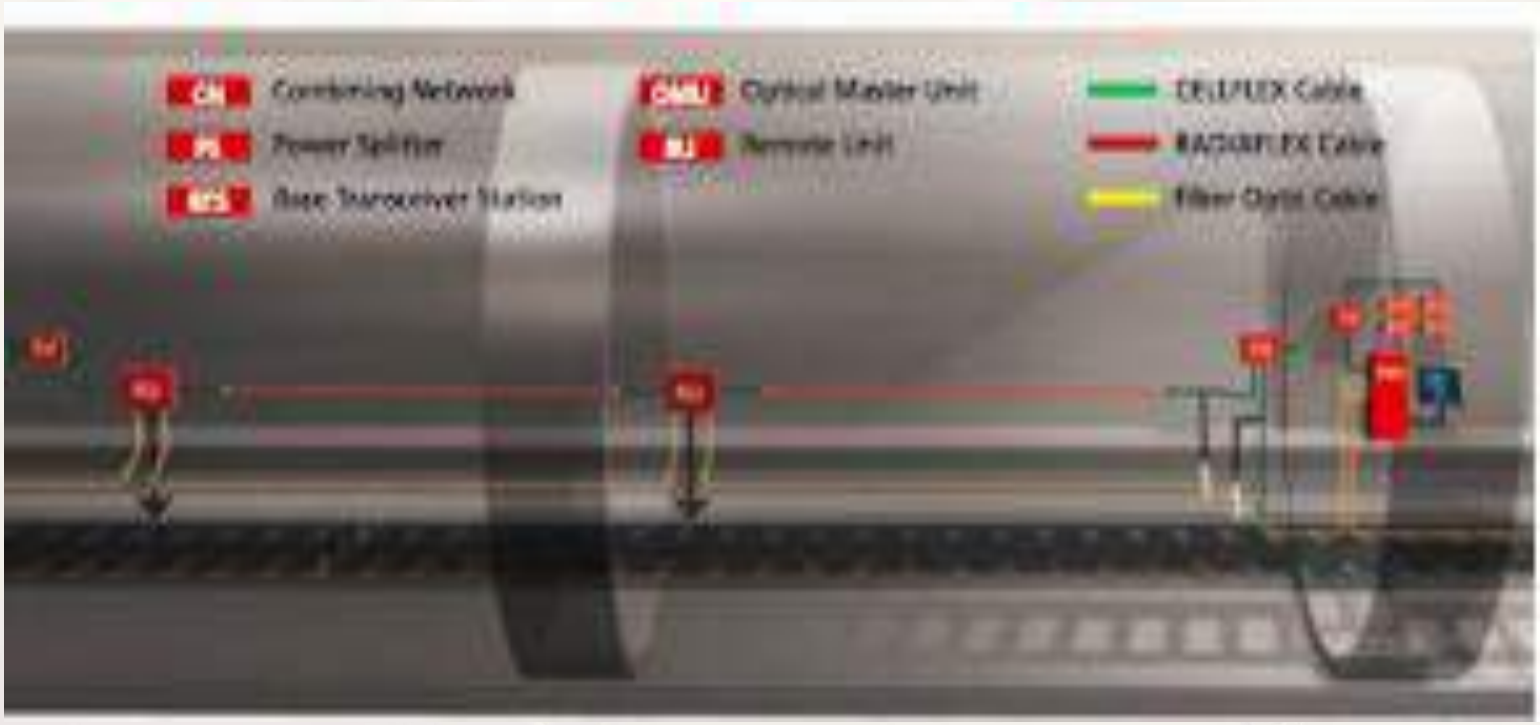
Provides a Supervisory Signal to the fire alarm panel for the following conditions:

(1) AC Power Failure
(2) Signal Booster Failure
(3) Battery Charger Failure
(4) Low-battery capacity
(5) Power Supply Failure
(6) Antenna Malfunction
(7) Signal Booster Trouble

Tunnel Applications

- **Tunnels are long, narrow underground or interior spaces.**
- **DAS featuring *radiating cable transmission line is a better choice* to support uniform RF coverage inside tunnels.**
- **Some examples include:**
  - **Mine shafts and tunnels,**
  - **railway and vehicular tunnels,**
  - **underground passageways,**
  - **maintenance and utility shafts,**
  - **metros, and subways.**

Tunnel Illustration using F/O & Radiating Cable Courtesy of RFS



Shadowed Areas

- **Shadows can impede RF communications due to absorption or reflection from either terrain or man-made structures can be covered with a BDA using two antennas.**
- **A highly directional antenna links the BDA with the repeater.**
- **The other antenna, also directional, is aimed at and provides RF coverage to portables and mobiles within the shadowed area.**

Real World Applications

- Typical applications will usually contain elements of two or even three of the above listed applications.
- Courthouses will have large open Court rooms best covered with discrete omni-directional antennas.
- The Courthouse is often connected to the jail through long underground passages which are better covered with a radiating cable DAS.

Real World Example...

The Pima County, AZ Courthouse
EMR In-Building System over 25 Years Ago

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FCC Class A & B Definitions

- **A BDA is currently classified by the FCC as either:**
  - **Narrowband *Class A* (retransmit signals on one or more specific channels)**
  - **Broadband *Class B* (retransmit *any signals within its frequency band*).**
  - **The FCC rules specifically limit a Class A (channelized) Signal Booster bandwidth to no more than 75 Khz.**
  - **The FCC also makes distinction between Industrial versus Consumer BDA's. Signal enhancement products**

Class B BDA's

- A signal booster that amplifies multiple channels with a bandwidth greater than 75 KHz and could be many megahertz wide.
- Uses broadband amplifiers with common output power amplifiers.
- Composite output power.
- Automatic Gain Control.
- Maximum 5 watts output power per channel.
- Gain typically between 50 and 80 dB.
- Very low digital group distortion and propagation delay, typically less than 5 microseconds.
- Much lower cost per channel.
- Must comply with Human RF Exposure limits. Rule of thumb is to limit ERP of any single in-building antenna to +28 dBm composite power.
- Requires less power, making backup systems smaller and less costly.

Class B Registration

- **The FCC requires that non-licensees who seek to operate signal boosters must first obtain the consent of the licensee whose signals they intend to amplify.**
- **The use may be reflected, for example, by "a letter, email or other record sent from a licensee or agent of a licensee to an operator, owner, or installer of the Class B BDA acknowledging that the [Industrial Signal Booster] will retransmit the specified frequency bands of the licensee.**

- **The FCC requires that both new and existing Class B signal boosters be registered through the FCC Signal Booster Registration website. http://www.fcc.gov/signal-boosters/registration. Unregistered Class B signal boosters after November 1, 2014 will be subject to FCC enforcement action.**

Effects on Composite Power

Effects of Multiple Channels Composite Power on Class B Signal Boosters

- **BDA's are used to amplify multiple channels within a given *pass bandwidth.***
- **As a Class B signal booster the BDA's UL and DL passbands are wider than a single channels modulation bandwidth and may be many channels wide.**
- **The end result of the feedback driven gain adjustment is that the output power per *channel will vary in direct proportion to the input power per channel* when operating at maximum *composite* output power.**
- **The *more channels* incident on a Class B Signal Booster, the *less power* out per channel.**
- **It is reasonable to assume that 20 equal level carriers could occur in downtown Phoenix, so the coverage would be designed around a per carrier power level of 50 mW or +17 dBm.**
- **When there is *less activity* the coverage will *improve*.**

Effects on Composite Power- More

MORE Effects of Multiple Channels Composite Power on Class B Signal Boosters

- High level input signals can exceed the capability of the AGC circuits and/or the 3rd order intercept point of the input amplifiers in any type of signal booster leading to excessive IM products, out of band emissions, or even amplifier failure.
- Donor antenna - to - DAS antenna ***isolation should be at least 15 dB greater than the gain*** of the Signal Booster to prevent system oscillation.
- The basic EMR BDA gain is typically 60 dB meaning there needs to be a minimum of 75 dB of decoupling between the roof mounted donor antenna and the interior

Impact of Lower Level CH on Power

Impact of Lower Level Channels on Channel Power

- When doing a spectrum analysis it is not uncommon to see many low level 'undesired' channels that fall within the BDA's operational pass bandwidth.
- The best place to insert the spectrum analyzer is after the downlink input filter providing an accurate representation of the input spectrum seen by the amplifier after the spectrum shaping provided by the input filters and the narrowed aperture of the directional antenna.
- It is common practice to ignore undesired signals that are 20 dB or more below the desired channels.
- Table 2 demonstrates the ***insignificant impact*** of as many as 40 undesired channels upon the output level of the desired channels.

Donor Antennas

- Carefully choosing the donor antenna (yagi, corner reflector or parabolic) and mounting position can improve the desired channel levels and reduce the undesirable channel power levels.
- It cannot be said enough but, an antenna with high directivity and high front-to-back ratios should always be used.
- This includes locations where the benefits inherent in the gain of the antenna are not important because we are *looking for the directivity* and resulting narrowing of the antennas aperture.
- A factor to consider when choosing a location is identifying where the donor site is located.
- A *clear of line of sight* to where the donor signal originates is *highly desired.*

Distributed Antennas- DAS

- A DAS can be classified as either active or passive.
- An ***Active*** DAS is one which employs amplification of the UL and DL signals; the vast majority of deployed DAS are active systems.
- A ***Passive*** DAS is a viable approach under the correct set of circumstances.
- A passive approach can be considered when the repeaters are ***located close*** to the building or underground space requiring coverage.

Distributed Antennas- DAS Coaxial

- Coaxial cable is the common approach used to enhance coverage to portables operating in buildings.
- In a coaxial DAS scheme coaxial cable is routed from floor-to-floor and throughout the building in support of several antennas located within the building.

Products used to implement a coaxial DAS:

Splitters. These can be 2 way, 3 way, or 4 way splitters. These are meant to split power equally to each port: 50%/50% for a 2 way, 33%/33%/33% for a 3 way, and 25%/25%/25%/25% for a 4 way.

2 way Power divider

4 way power divider

Distributed Antennas- DAS Coaxial

- Products used to implement a coaxial DAS:

Splitters. These can be 2 way, 3 way, or 4 way splitters. These are meant to split power equally to each port: 50%/50% for a 2 way, 33%/33%/33% for a 3 way, and 25%/25%/25%/25% for a 4 way.

2 way Power divider

4 way power divider

Line taps. These can support splitting power unequally to 2 or more ports. From as much as 25%/75% to as little as 0.025%/99.975%.

Distributed Antennas- DAS Products

Products used to implement a coaxial DAS:

- ***Antennas***. While there are instances where a high gain directional antenna could be a good choice, most applications will deploy omni directional antennas. EMR manufactures a 1/4 wave omni with a ground plane and a dipole antenna. The application and design will determine which is a better choice. Antennas need to be located below any metal: ducting, conduit, etc. Locate antennas to minimize the chance of damage.
- ***Coaxial cable***. Larger diameter cable will present lower longitudinal loss which can be an advantage. However, larger cable means high cost per lineal foot, wider bend radius, ***and more difficult to route through standpipes and conduit. 1/2" coaxial cable provides a good compromise between insertion loss, cost per foot, and ease of installation.***

Other DAS Site Considerations

- Building code.
- Cable runs through building plenums should utilize plenum rated cable.

Jumpers will be needed from the coaxial cable to antennas, splitters, donor antenna, and the BDA.

- Concentrate cable runs and antenna locations to soft ceiling areas such as hallways.
- Ideally locate the BDA head-end within 100' of the donor antenna; if radiating cable NO CLOSER than 50'.

DAS Radiating Cable Insights

- Radiating cable is commonly used in applications that are typically long, with limited narrow coverage areas.
- Radiating cable DAS is similar in approach to a coaxial cable DAS and utilizes the same components to route signal throughout the desired coverage area.
- Typically, DAS designs incorporating radiating cable will have the portables operating within 10' of the cable.

FiberDAS

- A Fiber Optic (FO) DAS is another viable means to implement a coverage solution.
- Typical applications where a fiber DAS would be considered are campus applications.
- Such applications have several buildings which are located within fairly close proximity and they already have "SINGLE MODE DARK" fiber connecting each of these buildings.
- One building functions as the RF over-the-air repeater interface or *co-located repeater location,* which then feeds these other buildings through the existing dark fiber.

Information Need to Design the BDA

1. Repeater transmit frequencies
2. Repeater receive frequencies
3. Location of sites where repeaters are located in relation to the building to be covered.
4. Repeater ERP
5. Distance between the repeater and the building to be covered
6. Signal level on the roof of the building to be covered

   Loss = -36.6 - 20log(frequency MHz) - 20 log(distance in miles)

1. Gain of the BDA required to implement coverage, provided by customer, or from the DAS design.
2. Knowledge of local building code requirements which the BDA and DAS must meet.
3. Nearby, in band repeater transmitters that are within 20 dB of the signal level of the desired repeater transmit frequencies.
4. Gain of the directional antenna to be used in dBd.A.

Information Need to Design a DAS

1. Cable to be used for the application. Often determined during the DAS design.
2. pdf of the building to be covered by the BDA and DAS.
3. Distances specified on the drawing to determine an accurate scale.
4. The pdf should show where hallways and passageways are located.
5. Note where the BDA head-end is to be located within the building.
6. Location of vertical chases within multi-story buildings.
7. Building materials used in the construction of the building and walls.
8. Knowledge of special rooms within the building requiring special care; *such as radiology departments in a hospital.*
9. Make note of any metallic backing on ceiling tiles, wall paper, or plaster board.

Note areas within the building that do not require coverage.

Commissioning the System

- Many applications require that the system undergo compliance testing as the installed BDA system and DAS represent a significant investment.
- Even if not required base line system readings should still be taken. Doing so will make future trouble shooting of the system easier as well as aiding in redesign of the DAS due to building remodeling or expansion.
- The ideal of 100% coverage and 100% reliability is not practical economically and almost impossible to achieve. It is appropriate to use minimum signal level values similar to what is acceptable for outside coverage.
- Most ordinances set RF signal levels near -95 dBm, which is sufficient to approach 95% reliability.

DAQ & Signal Strength Testing

There are two types of coverage measurements when evaluating In-Building Systems Delivered Audio Quality (DAQ) and Signal Strength Test (SST).

- Again, if using SST most ordinances set RF signal levels near -95 dBm, which is sufficient to approach 95% reliability.
- DAQ is a subjective performance test. DAQ definitions follow:

1) Unusable, speech present but unreadable.
2) Understandable with considerable effort. Frequent repetition due to noise/distortion.
3) Speech understandable with slight effort. Occasional repetition required due to noise/distortion.
3.5) Speech understandable with repetition only rarely required. Some noise/distortion.
4) Speech easily understood. Occasional noise/distortion.
4.5) Speech easily understood. Infrequency of noise/distortion.
5) Speech easily understood.

Coverage Confirmation

RF coverage based on RF signal strength measurements provides an accurate, statistically valid, repeatable, objective, and cost-effective method to verify that user coverage requirements are met by the installed BDA and DAS.

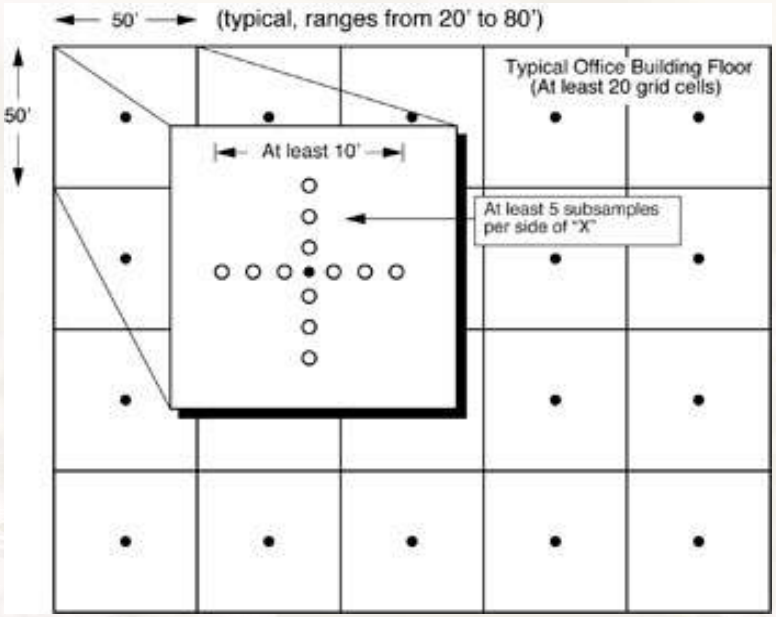
- To conduct DL testing, the wireless test equipment should consist of a single antenna mounted to a handcart 3 - 4 feet in height. This is a suitable simulation of a portable radio carried at the hip.
- A suitable Spectrum Analyzer, Network Analyzer, SSI, or other suitable, calibrated test equipment capable of accurately reading signal strength to -100 dBm or less.
- To conduct uplink testing, a signal strength measurement can be taken from an unused receiver multicoupler port, or by means of a directional coupler or "tap" at the receive port.

Many agencies already employ a suitable testing procedure for acceptance testing within the area covered by the BDA and DAS. The following is representative of what may already be in place however, in the event there is no established requirement it would be advisable to adopt something similar for base line testing of the installed system. See Matrix slide that follows.

System Maintenance

- The BDA should be ***checked annually*** to verify operation of all active components of the in-building radio system, including but not limited to amplifiers, power supplies, and back-up batteries.
- Amplifiers shall be tested to insure that the gain is the same as it was upon initial installation and acceptance. The original gain shall be noted and any change in gain shall be documented.
- If supplied with back-up batteries and power supplies these shall be tested under load for a period of one hour to verify that they will operate during an actual power outage.
- Active components shall be checked to determine that they are operating within the manufacturer's specifications for their intended purpose.
- Maintain documentation of all tests performed.

DAS Coverage Testing Matrix



- Each floor of the building shall be divided into a grid of approximately 20 equal areas. A maximum of 1 of these 20 equal areas will be allowed to fail the test. If more fail, a 40 area test must be conducted; *add nodes or redesign if failure of more than 2 equal areas.*
- The BDA UL and DL system gains should also be verified against the factory data and then documented.

About RF Interference

- Interference is always present in the increasingly RF saturated world.
- Non-linear joints, dissimilar metals, rusting; even chain link fences can cause interference and wreak havoc on systems coverage and performance.
- And, recently revealed...LED Light Bulbs...yes VERY **GREEN** Energy Conservative but a big generator of RF Interference particularly in the 150-174 MHz VHF Public Safety, etc. Band.

Takeaway- KNOW the building environment and frequencies to be used. It could be a very serious consideration for the safety and communications of/for "First Responders".

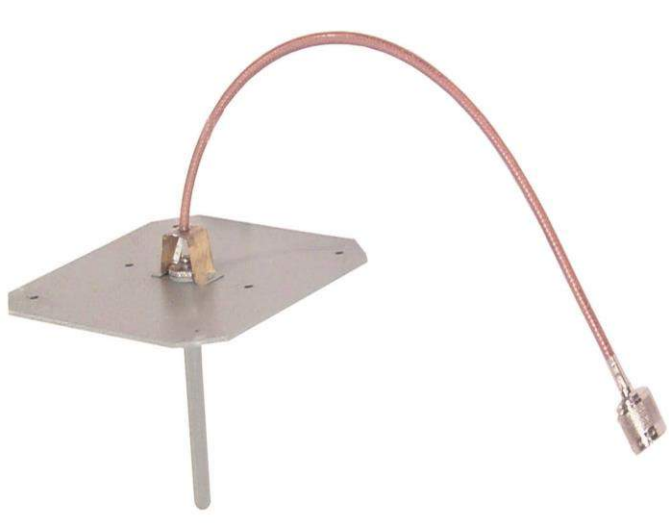
About RF Interference- LED's

There are plenty more of these LED type devices out there, causing interference to VHF Public Safety Radio Systems. ONE Ref: State of Missouri VHF Public Safety System

1. The established testing protocols may not be discover this RF emission problem and
2. **Unscrupulous importers/vendors may be ignoring this aspect of their products and cloak themselves in the "green-ness" of LED lighting.**
3. **THIS A BIG CONCERN!**

Indoor Antennas- DAS Products

Illustration(left)- Quarter Wave 800 MHz Indoor Antenna



Illustration(right)- Dipole 800 MHz Indoor Antenna

Mandated Battery Back-up

Depending on the Regulatory Environment, the Authority have Jurisdiction (AHJ) for the city, town, county, township, may mandate battery back up.

EMR can provide an optional 12 or 24 hour battery backup.

Typical EMR Corp. Certification Question Examples...

1. A Class B Booster is a “Non-Hetrodyning” Device- T or F
2. The maximum power output of a BDA is how many dBm?
3. How frequently must a BDA be checked?
4. Is documentation of all tests required?
5. What is “minimum” desired Signal Level at the rooftop where the donor antenna is placed?
6. Should the donor antenna have a clear unobstructed path back to the donor site?
7. Which system is harder to design? VHF or 800 MHz
8. Why would it be harder to design?
9. What does AHJ mean?
10. If you have more than ONE signal passing through the BDA, what affect does it have on ALL the signals?