Using Signal Boosters for Outdoor Coverage Solutions for Public Safety

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Introduction:
FCC rule 90.129 (d) specifically authorizes the use of Class B wideband signal boosters (also known as bi-directional amplifier – BDA) in rural and remote locations. (see Appendix B)

Rule 90.219 (a) allows signal boosters to be used for fill-in coverage but not to extend the range of the system.

These rules provide the system designer one method of addressing shortfall of coverage (dead spots) within the desired area of wireless communications.

This document introduces the system designer to the various possibilities as well as disadvantages of deploying signal boosters for outdoor coverage enhancement.

As will be become evident, theses applications demand well designed installations and oft touted ‘automatic’ control of signal booster functionality can be problematic.

Appendix A is a list of definitions of unique terms used in this document.

There is a very wide selection of signal boosters available to the system designer. This section will attempt to explain the differences in different types of signal booster and, more importantly, the different specifications and what impact these differences may have on the performance and costs of the signal booster site.

FCC Signal Booster Classifications
The FCC categorizes signal booster into two general types: (See Appendix B)

Class A: A “Narrowband” design only amplifies the channel(s) of the associated licensee with an ERP limit of 5 watts or less per channel. The accepted definition of a “channel” is the smallest spectrum bandwidth used by a radio when communicating. A wireless system may be authorized by then FCC to operate on many different channels. It is not uncommon for a public safety system to utilize 20 or more channels.

Current FCC bandwidth allocations for one channel are 25 KHz or 12.5 KHz. 6.26 KHZ wide channels are being implemented by the FCC as hardware becomes available. It is important to remember the FCC has implemented a plan to eliminate existing 25 KHz wide allocations.

Common terms for Class A signal boosters are “Channelized” and “Channel Selective”.

Technologies include Hetrodyne, DSP and, in the 150 – 174 band, crystal filters.
**Class B:** A “broadband” design that amplifies a spectrum window (passband) that processes more than one channel. These channels may consist of only the licensees contiguous channels or a combination of the licensees channels and other channels that appear within the passband. The FCC rules state it is legal to amplify other licensees channels using a Class B so long as that does not cause interference to the other licensees.

Common terms for Class B signal boosters is “Broadband” and “Band Selective”.

Filter technologies include cavity filters, combline filters, saw filters and DSP.

**Spectrum constraints:**
Part 90 signal boosters are approved by the FCC to be used within licensed (FCC authorized) wireless systems operating above 150 MHz. It should be noted many sources of 800 MHz products are available as derivative, secondary, devices from manufacturers of Cellular radio service devices. However, there is a limited number of sources that have products and experience in the lower frequency bands and specialize in Private Radio/Public Safety system applications in all FCC approved bands.

Each FCC band of spectrum allocation for private radio has distinctive characteristics that impact upon the fill-in application and the related signal boosters.

In the VHF (150 MHz to 174 MHz) band, there is currently no FCC organized duplex frequency plan. The results is there is no specific order of different uplink and frequencies or which frequency is used as the downlink or uplink channels. Signal boosters operating in this band are inherently custom designed.

In the UHF band duplex channels in the 450 to 470 MHz range have 5 MHz separation between uplink and downlink frequencies. In the 470 to 512 MHz range the separation is 3 MHz. 470 to 512 MHz channels are only licensed within a 50 mile radius of the 13 largest urban areas and outdoor fill-in requirements are therefore less frequent than in other band segments.

700 MHz band channels and equipment has just been approved by the FCC and availability has been delayed until after June 12, 2009 since incumbent television stations operating on these frequencies must be relocated to other spectrum bands. In most instances fill-in in this band is very similar to 800 MHz band applications and specifications. The duplex transmit – receive separation is 30 MHz.
800 MHz band alone: Channels in this band are duplex pairs with 45 MHz transmit to receive separations. This separation is the same as used in the cellular band and this has resulted in many cellular signal booster designs being retuned to operate in this band. It should be noted there are many technical and operational differences between the cellular band and the LMR 800 MHz band and most retuned cellular signal boosters designed for consumer use have lesser features and performance than that required by LMR users, especially public safety licensees. In-building codes issued by the International Fire Code and National Fire Protection Association in 2009 include specific signal booster requirements for public safety applications.

When serving public safety licensees, 700 / 800 MHz band combinations will probably arise and should be considered as one band in new applications. In this case the uplink frequencies will be from 794 to 824 MHz and the downlink frequencies in two separated bands; 764 to 776 and 851 to 869 MHz. (see “retuning” also)

**Typical Outdoor Coverage configuration and common terminology:**

![Typical Outdoor Coverage Solution](image)
Typical Outdoor Signal Booster Site components:

Donor Antenna:
A highly directional antenna is directed towards the Donor site. The purpose in using a directional antenna is multifold:

a. Highly directional antennas are also inherently high gain types, such as Yagi, corner reflector and parabolic. Antenna gain improves the signal level between the two sites. Higher signal levels relax the Donor to signal booster gain requirements and service area downlink signal levels as a general rule.
b. Directivity focuses the signal booster input towards the donor and minimizes interactions with other distant sites.
c. Vertically polarized gain antennas exhibit higher isolation between antennas when using vertical antenna separation.

Note in the illustrations, the Donor Antenna is below the Service antenna. This method is used to increase the Service coverage range using the highest level on the antenna supporting structure. These positions can be reversed when it is necessary to obtain a better Donor path.
Directional Donor Antennas Reduce Undesired Site Signals

Service Antenna:
The service antenna in the illustration is a panel type antenna but other types may be used. The selection of the service antenna depends mainly upon the dimensions of the donor area relative to the signal booster site. Antenna patterns may be omni-directional, bi-directional, off-set (oval) or directional. The beamwidth of the service antenna should be the narrowest possible that will cover the service area. Excess beamwidth usually wastes signal level.

When the service area is obstructed by terrain (in a valley, canyon, etc.) it may be advantageous to add downtilt to the service antenna to focus the main lob of the service antenna into the service area. With sharp elevation changes and some types of antennas (directional) downtilt angles usually requires mechanical downtilt.
**Donor to Service Antenna Isolation**

The signal booster acts as a gain block (amplifier) with the same input and output frequencies. If the isolation (loss) between the output and the input is equal or less than the gain of the amplifiers, this is called positive feedback and ‘self-oscillation’ will occur.

When oscillations occur, uncontrollable high level signals are generated by the signal booster. This causes interference to the licensee as well as others operating within the passband frequencies of the signal booster.

If the isolation (loss) between the output and the input is greater than the gain of the amplifiers, this is called negative or degenerative feedback and ‘self-oscillation’ cannot occur.

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**DONOR TO SERVICE ANTENNA ISOLATION**

In accepted practice the desired isolation between the donor and service antenna is the overall gain of the amplifier's highest operational gain setting plus 15 dB or more. (20 dB is becoming common in digital systems)

The isolation includes the vertical and horizontal spacing between the antennas and the antenna gain or loss directly below and above the antennas. High gain antennas provide the greatest vertical isolation. The practical limitation of achievable isolation can require the signal booster gain and/or output power level to be reduced.
Antenna to Antenna Isolation Measurement:
The measurement principle is straightforward: inject a known signal level on an operating frequency into one antenna and measure the resultant level on the other antenna. Since the uplink and downlink path losses are reciprocal (the same loss in both directions), you only need to measure in one direction. In a wide band system, the desired bandwidth should be scanned.

The isolation value over a wideband may vary as much as +/- 5 dB, so if only one frequency is tested, subtract 5 dB from the measured isolation to account for this effect.

Common antenna – antenna isolation test method shown below.

Oscillation Prevention
The best approach to assuring sufficient antenna isolation to minimize the possibility oscillations is simply to use good system design practices.

Some manufacturers are attempting to overcome poor system designs and installations with ‘anti-oscillation’ schemes. These approaches can be implemented in both analog or digital (DSP) designs.

The most often used anti-oscillation attempts employ Automatic Gain Control (AGC) level sensing, which is then used to maintain a relatively constant gain of the signal booster. An Output Level Control (OLC) is different than an ALC circuit as it monitors the output power and when the power amplifiers approach their limit of linearity of the signal booster amplifier(s) a ‘control voltage’ is applied.
to an electronic attenuator located near the input of the amplifier(s). This reduces the signal booster gain.

In AGC circuits, some circuits are designed to be 'anti-oscillation' circuits by lowering gain to prevent oscillation. This can only occur until the maximum AGC attenuation is exceeded, therefore the more AGC the better. Most signal boosters have 30 dB AGC or OLC while some have as much as 60 dB.

![Figure 7](image)

There are three actions that can be taken when the AGC/OLC control voltage indicates excessive levels:

a. Reduce gain as much as possible in direct and near instantaneous relationship to the output level: This approach does not prevent oscillation but is the best for a properly designed system where oscillations cannot normally occur. (I.e. gain plus 15 dB antenna to antenna loss.)

This approach handles most transitory excessive input level excursions, (such as an unexpected high power mobile transmitter near the input antenna, etc.) which could appear the same as an oscillation condition to the AGC control voltage sensor. In other words, this approach cannot be easily fooled by non-oscillation input level sources.

This approach can also optimize ACG control loop response times. These timings include (1) the delay before gain is adjusted when a high level occurs (attack response delay), (2) the delay before gain is restored to normal following the removal of an excessive input signal, and (3) the gain ‘settling time’ which is a damped wave effect following a rapid control voltage change. The AGC response timings are very important when dealing with short bursts of high speed data.

b. Reduce gain and set the new gain level as the permanent gain setting of the signal booster. Obviously, a rare transitory high level input could result in a long term lower gain setting that could render the signal booster useless. To overcome this unacceptable drawback, some have resorted
c. A recurring attempt at controlling oscillations is sometimes called the ‘smart AGC’ approach. This scheme is similar to item b, above, but the attenuation level is slowly restored to its maximum setting over some defined period of time.

This approach could set up the worse possible scenario when the lack of antenna isolation is causing oscillations. As you can see from the illustration below, repetitious bursts of interference can occur. The source of such interference would be very difficult to locate and correct.

![Diagram of AGC oscillations](image)

d. The AGC circuits and gain level settings of signal boosters must also anticipate transitory input ‘spikes’ that occur in some digital systems such as iDEN (TDMA). These very short (microsecond) excursions are caused by random coincident addition of digital bit power. Common practice where iDEN stations are nearby is an allowance of 10 to 15 dB above normal levels. Most AGC circuits cannot respond fast enough to limit these spikes, making proper antenna to antenna isolation the best design.

**Signal Booster Generated Noise**

Uplink noise must be acknowledged since it may interfere with other licensees. Additionally, noise appearing on the users own channels when the signal booster has no input can desense a nearby donor site. When this occurs, the receiving range of the donor site is reduced.
Class A signal boosters can cause receiver desense in the same manner as any nearby transmitter. Some configurations keep the output power amplifier activated for a short period (i.e. 0.5 to 5 seconds) after the input signal is removed. The purpose of this is to eliminate the attack delay between successive communications exchanges and to reduce rapid load changes to the power supply. This period is sometimes called the “holdover” period. During the holdover period an unmodulated signal at the signal boosters output power level is seen by the donor receiver. These signals compete with other uplink signals form other signal boosters and system mobiles and potables.

Holdover interference may be difficult to identify and symptoms can appear as random message failures.

If multiple Class A signal boosters are directed to the same donor, the holdover signal can become very destructive.

One solution to managing Class A signal booster holdover interference is to enable the power amplifiers continuously and reduce output power to emulate the uplink signals from a Class B signal booster.

Class B signal boosters generate continuous low level noise. This is inherent with any continuously enabled broadband amplifier.

Over 20 years of industry experience with Class B signal boosters has resulted in extensive knowledge of this effect and how to minimize its impact.
Consider a typical Class B signal booster specifications:
- Passband Bandwidth: 3 MHz
- Center frequency: 867 MHz
- Gain setting: 80 dB
- Noise Figure: worse case: 6 dB

Total bandwidth output noise level = -22.23 dBm
25 KHz channel passband noise level: -44.02 dBm

Free Space separation required to reduce signal booster generated noise to –110 dBm = < 80 feet or < 1000 feet to get –124 dBm.

In many cases the ambient noise from other sources at the receiver are greater than any signal booster generated noise.

A common error in measuring Class B output noise is to measure the power over the signal boosters total passband bandwidth, not the power level that would be seen within the receiver's passband bandwidth.

Since Class B signal booster noise is constant and low level it is easy to design the system for minimum impact on the donor as well as quickly locate an offending signal booster.

**Passband Bandwidths:**

Using the FCC Class A and Class B definitions, we find these anomalies:

a. A signal booster that passes several adjacent channels licensed to the same licensee can be legally a Class A signal booster although the passband is wider than one channel bandwidth. However, if the channels being amplified are not those of the licensee it is a Class B.
b. Any signal booster, including DSP types, are legally Class B signal boosters when the passband is adjusted to pass more bandwidth than the licensee's channels are approved to occupy. This situation arises when the bandpass of a Class A signal booster's passband bandwidth must be increased to reduce group delay to an acceptable amount. This is not an uncommon practice for channelized signal booster delay optimization.

![Diagram of passband and channels](image)

Obviously adjacent channel protection is reduced when this technique is used.

**Group Delay:**
Group delay within a signal booster can create multipath interference due to the differential of the time of arrival signals direct from the donor site and the signal from the boosters output. When the signals overlap there can be serious 'dead spots' of no communications. Each system type (ASTRO, Open sky, etc.) has a different tolerance of this differential. When the delay in the signal booster is below that threshold, the radio environment is the same as simulcasting and there are no dead spots. This effect is very important when the radio system is a simulcast type. Group delay must be reduced to a period that is reliable under all operating conditions to be reliable.

Signal booster delays of less than 15 microseconds are preferred, most older systems need < 25 microseconds.

The impact of multipath propagation delay differential effect on digital signals is discussed in detail in the TIA TRB-88B report, section 8.9.
Although outdoor fill-in applications are obviously prone to set up multipath situations, multipath may also occur with in-building systems. Delayed signals leaking outside from widows, doors and other openings can interact with vehicles and portables near the outer perimeter of the structure. This can be a special problem for first responders using command vehicles in the adjacent street.

Figure 12
Impact of signal booster delay in Multipath and Simulcast situations

The propagation delay added by a signal booster can result in a difference of time of arrival that is beyond a system's tolerance. This occurs if the direct signal and the repeated signal overlap. The illustration below shows this condition occurring at the side of a hill. This is also called a multipath zone.

This effect can be eliminated if the added delay of the signal booster is very small, typically less than 25 microseconds.

Other ways to reduce this effect is to reduce the area of overlap by careful antenna selection, antenna orientation and reduction of the signal booster output power.

Generalized estimations of delays in signal booster type are:
- Class A, (channelized) signal booster set to 25 KHz channel bandwidth: more than 50 uS.
- Class A, (channelized) signal booster set to 12.5 KHz channel bandwidth: more than 100 uS.
- Class B (band selective) signal booster with > 0.5 MHz bandwidth window: Less than 5 uS.
Reported manufacturers maximum delay recommendations in simulcast and/or multipath environments:

Motorola : 35 uS, with a maximum of 70 uS.
M/A Com : 32 uS or less.

Obviously, an installation with high delay is subject to not working properly if the radio system specifications become more restrictive in the future.

**NOTE: Specifications will vary. Consult manufacturer for exact delay information.**

**Power Consumption**
It is not uncommon for remote signal booster sites to operate from limited power services such as solar power/battery combinations.

The greater the output power, the greater the power supply requirement.
Class A signal boosters usually consume the most power.
Class B signal boosters have the least power consumption

**Impacts of Amplifying Multiple Channels in Class B Signal Boosters**
Some have concerns about the output power level of Class B signal boosters which often pass channels other than the licensees.

**Power Per Channel:** The composite output power level of Class B signal booster will vary according to the power distribution seen at the signal boosters input and this also varies the output power per channel.

This effect can be minimized by good system design practices as evidenced by thousands of successful and reliable Class B deployments.

Assuming the amplified channels are of comparable level, the approximate relationship of multiple channels to output power in a typical Class B signal boosters is:

- 1 channel : +34 dBm out per channel
- 2 channels : +31 dBm out per channel
- 4 channels : +28 dBm out per channel
- 8 channels : +25 dBm out per channel
- 16 channels : +22 dBm out per channel
- 32 channels : +19 dBm out per channel.
- etc……..
In other words, in a 20 channel trunked public safety system, it would take 20 more same level carriers from other licensees to reduce the Class B signal boosters output per channel by approximately 3 dB.

Proven system design practice always includes conservative estimation of output power levels.

**Interference due to amplifying other licensee's channels:**

The FCC approves the amplification of other licensees channels within Class B signal boosters *provided* this does not interfere with other licensees.

Due to the lack of a FCC band plan in the VHF band, this band has the highest possibility of interference occurring. In extreme situations it may prove necessary to use channelized signal boosters in the VHF band. However if the offended channel is an adjacent channel, a channelized booster may not be able properly pass digital signals and protect the adjacent channels at the same time.

The FCC channel plans for public safety channels above 450 MHz aggregate these channels into more concentrated spectrum windows. Additionally, aggressive enforcement of selection of public safety channels by public safety frequency coordinators (such as APCO) reduces the probability of co-channel or adjacent channel users near the licensees area of operation.

Reports of signal booster interference between public safety agencies is very rare due to their excellent frequency coordination discipline.

Note: If a signal booster is cited for oscillation, the FCC cites the signal booster for 'operating on unauthorized frequencies'. There are no specific provision in the rules to cite "oscillation". The FCC cites the result, not the mechanism. This terminology leads some to the erroneous conclusion a citation was issued for amplifying some others channels in a Class B signal booster.

**Power level limitations:** FCC rules and OSHA regulations deter high power levels. FCC rules limit signal boosters to 5 watts (+37 dBm) ERP per channel. The high gain antennas and low coaxial cable losses typical of outdoor signal boosters provide about 10 dB gain, therefore the maximum legal output power per channel from a signal booster is approximately ½ watt per channel (+27 dBm).

Signal booster with more than 5 watts ERP on any channel must be licensed as base stations to legally operate. Base stations cannot be operated without a specific FCC authorization. Licensing is a time consuming and expensive process.
OSHA RF exposure limits are seldom applicable unless one of the gain antennas is very near a location occupied by humans, such as office window in an adjacent building, or high signal booster output power is used.

**Interoperability:** The wider passband bandwidths of Class B signal boosters can offer instant availability and interoperability for emergency situations. Guest public safety licensees operating in the same band can be handled by properly designed Class B signal booster on an as needed basis.

Conversely, Class A channelized signal boosters cannot readily handle such situations. A channel frequency cannot be reprogrammed without sacrificing an existing channel. Additional channels may not be added easily or rapidly.

**Donor Site Desense due to Multiple Signal Boosters:** Cellular system operators were the first to suffer the impacts of many signal boosters being directed to the same donor site. As public safety and enterprise systems add more signal boosters this is becoming a concern for them as well.

Estimating multiple signal booster desense is complex. One Excel overlay for this purpose is available from the Jack Daniel Company.

The level of interference is the composite power of all signals received from the associated signal boosters. When idle (not amplifying an input signal or during any holdover period) Class A signal boosters present the least interference. Interference caused by Class A signal boosters is intermittent and difficult to identify.

Class B impacts are relatively constant and more predictable. Class B peak interference can be less than Class A. Since Class B signal boosters outputs are relatively constant, interference is easier to locate.

The use of multiple signal boosters focused on one donor must be analyzed to assure optimum overall system performance.

**Summation:**

The outdoor signal booster system designer must be alert to many variables and conditions as well as FCC rules.

There is no one solution to all requirements. Some applications are best served by Class A channelized signal boosters while Class B signal boosters are the best choice for other situations.

Since Class B signal boosters have been successfully used for outdoor coverage for more than 15 years, their performance and configurations are well know.

For additional information, contact the Jack Daniel Company 800-NON-TOLL.
Appendix A: Definitions

Automatic Gain Control (AGC): A circuit that samples the output of an amplifier, generates a corresponding “control voltage” then applies the control voltage to an electronic attenuator at the amplifier input and therefore reduces the gain of the amplifier.

Band: A block of spectrum that includes many adjacent wireless channels.
Common Part 90 bands include:
VHF : 150 to 174 MHz
220: 220 to 222 MHz
UHF : 450 to 512 MHz
700 : 742 to 764 (DL) and 776 to 896 (UP) MHz
800 : 806 – 824 (UL) and 851 to 869 (DL) MHz
900 : 896 to 901 (UL) and 935 to 940 (DL) MHz

BDA: An abbreviation for Bi-Directional Amplifiers which is an often used description of a signal booster. There is no difference between a “signal booster“ and a “BDA”.

BTS: A term used in the cellular industry to describe their equivalent of a repeater station. This term isn’t normally used by non-cellular users and equipment suppliers.

Cellular band: 824 to 849 (UL) and 869 to 894 (DL) MHz. This band is only discussed within this document to the extent they technically interact with Part 90 frequencies. This is especially important where the cellular frequencies are adjacent to Part 90 frequencies at 824 and 869 MHz.

Channel: The smallest spectrum bandwidth used by a radio when communicating. Typically current FCC allocation for one channel is 25 KHz or 12.5 KHz. 6.26 channels are being implemented by the FCC as hardware becomes available. A wireless system may be authorized to operate on many different channels. It is important to know the FCC has implemented a plan to eliminate 25 KHz wide allocations.

Degradation: A reduction in receiver sensitivity caused by undesired signals (usually noise) appearing at a receiver input.

Downlink (DL): The direction of communications, FROM the Donor site (base station) TO the handsets and mobiles operating within the obstructed area. See Uplink also.

Duplex channels: Two single channels are normally paired to enable a repeater type donor (base station). Repeater stations is the most common type of donor
station used for signal booster applications. On duplex channels, donor station s transmit on the Downlink frequency(s) and receive on the Uplink frequency(s). The portables and mobiles transmit on the Uplink frequency(s) and receive on the Downlink frequency(s).

FCC : Federal Communications Commission

LMR (Land Mobile Radio) : A generic term describing private/public safety wireless systems operating on channels authorized (licensed) under Part 90 rules.

Nextel Band: A term used in the cellular industry to describe the 800 MHz band. This is because Nextel provides cellular-like services on frequencies that are randomly interleaved within the 800 MHz band. This term isn’t normally used by non-cellular users and equipment suppliers.

NPSTC (pronounced “nip stick”) band: The National Public Safety Telecommunications Committee, established by the FCC, defines exclusive public safety use of a 3 MHz wide spectrum segment within the 800 MHz band. Currently the NPSTC band is 821 to 824MHz (UL) channels paired with 866 to 869 MHz (DL) channels for duplex operation. When FCC’s Retuning order (see “Retuning”) is completed, these frequencies will be shifted exactly 15 MHz lower; 806 – 809 MHz (UL) and 851 – 854 MHz (DL).

Part 90: The FCC rule section that lists the operational methods and spectrum allocations used by private land mobile radio (LMR) wireless systems such as enterprise and public safety systems. Cellular and PCS services are regulated by a separate part, Part 22 and Part 24. In addition to this part, other parts regulate the marketing limitations and equipment approval methodology required for Part 90 radio equipment.

Retuning: Due to interference between cellular-like licensees (i.e. Sprint-Nextel) operating on scattered channels interleaved with other licensees in the 800 MHz band, the FCC has ordered licensees to relocate to more compatible channel assignments. This process is commonly referred to as “retuning”. This is a complex multi-year task which is underway now and scheduled to be completed in approximately 4 years. When completed, the existing public safety users will be relocated to the lower channels in the 800 MHz band and cellular licensee channel will be relocated to the upper portion of the 800 MHz band. This activity is important to signal booster users because installed devices will need to be retuned also for optimum operation and compliance to FCC rules.

Simplex channels: Channels which use a single frequency for transmit and receive. Repeater type donors stations cannot be implemented for technical reasons.
Uplink (UL) : The direction of communications, To the Donor site (base station) FROM the handsets and mobiles operating within the obstructed area. See Downlink also.
Appendix B: FCC Signal Booster Regulations

Sec. 90.219 Use of signal boosters.

Licensees authorized to operate radio systems in the frequency bands above 150 MHz may employ signal boosters at fixed locations in accordance with the following criteria:

(a) The amplified signal is retransmitted only on the exact frequency(ies) of the originating base, fixed, mobile, or portable station(s). **The booster will fill in only weak signal areas and cannot extend the system’s normal signal coverage area.**

(b) Class A narrowband signal boosters must be equipped with automatic gain control circuitry which will limit the total effective radiated power (ERP) of the unit to a maximum of 5 watts under all conditions. Class B broadband signal boosters are limited to 5 watts ERP for each authorized frequency that the booster is designed to amplify.

(c) Class A narrowband boosters must meet the out-of-band emission limits of Sec. 90.209 for each narrowband channel that the booster is designed to amplify. Class B broadband signal boosters must meet the emission limits of Sec. 90.209 for frequencies outside of the booster's design passband.

(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.

(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 Sec. 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 Sec. 90.173(b).

[61 FR 31052, June 19, 1996, as amended at 63 FR 36610, July 7, 1998]