Dual-band in-building wireless networks

Industrial maintenance and safety needs often require multiple communications systems. Getting them to co-exist on one network doesn't have to be costly.

By Steve Blum

Bi-directional amplifiers, or *signal boosters,* offer a fast, inexpensive way to improve in-building coverage for cellular, SMR and PCS service providers. Combining these services onto a single distribution network with BDAs can save thousands of

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dollars for operators and building owners.

Combining PCS and 800MHz services is fairly easy, provided that the components of the distribution network are wideband or dual-band.

Most 800MHz components are wideband enough to accommodate cellular and SMR business bands. However, combining 800MHz cellular and 800MHz SMR BDAs can create a *gain path* between the

SMR downlink and the cellular uplink. This will cause an oscillation that will shut down or destroy the BDAs.

The city of San Diego faced such a problem. It needed coverage at its new water-reclamation facility for its 800MHz city maintenance frequencies and for B-band cellular. Most of the facility is situated below grade and is surrounded with thick concrete walls, so no signal was getting through.

A single distribution network would limit the installation cost. The problem is that most bi-directional amplifiers are fairly broadband, as shown in the passband curve graphs on the facing page.

When these units are connected

as shown in the accompanying block diagram, a gain path develops at 849MHz and 851MHz.

An SMR 851MHz base transmit signal received by the donor antenna will be amplified in the downlink passband of the SMR band BDA. The two-way splitters have 25dB of isolation, but the cellular-band BDA has at least 70dB gain at 851MHz.

The result is a gain loop with 150dB of gain and only 50dB of isolation. Within a short time, the power amplifiers in both of the BDAs will be overdriven, and, if they lack protection circuitry, they will overheat and fail.

That's the *good* news. If the power amps did *not* shut down or fail, the intermodulation created by the oscillation would cause interference in both bands. Something similar results when a cellular mobile transmits at 849MHz.

To prevent oscillation, the goal is to provide a level of loop attenuation 20dB above the level of gain at any given frequency (10dB minimum). In this example, 849MHz and 851MHz represent the worse case.

In the installation at the water reclamation facility, separate donor antennas were used. Because the respective base sites were located in opposite directions, separate antennas were needed anyway, and their use provided an opportunity to increase the isolation in the loop.

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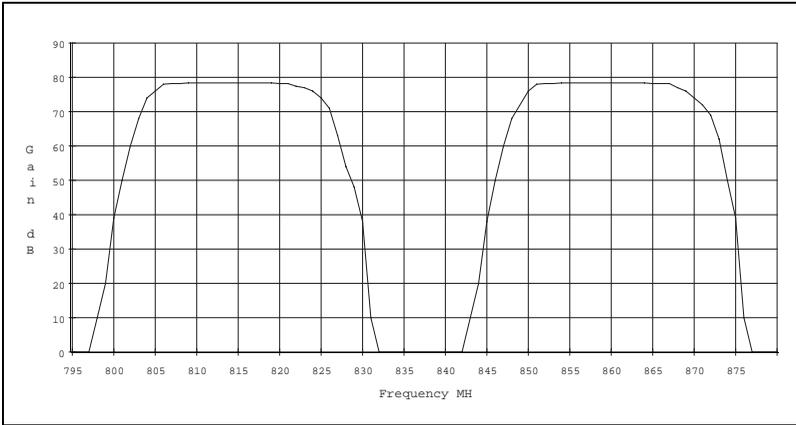
Typical gain vs. frequency—800MHz SMR booster.
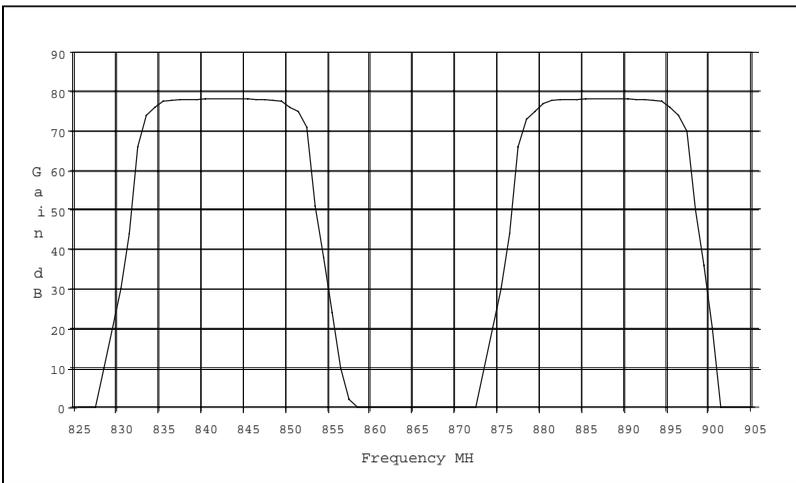
Typical gain vs. frequency—800MHz cellular B-band booster.
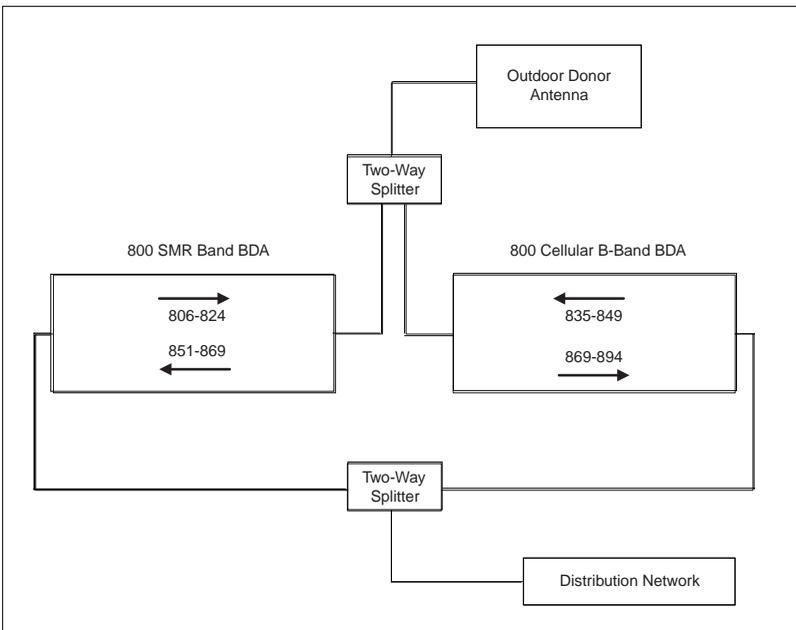
When the bi-directional amplifiers are connected, a gain path develops at 849MHz and 851MHz.

Separating the donor antennas by a great distance at the San Diego site was not practical.

Typical gain vs. frequency—800MHz cellular, B-band specific.

Using directional donor antennas is always recommended with BDAs—to increase the desired signal strength and to reduce the potential for interference. Suitable antennas include corner reflectors, yagis and directional panel antennas. Radio Frequency Systems, for example, offers a panel antenna called "Maximizer" with a suitably high front-to-back ratio.

If it is possible to separate the antennas vertically and horizontally, and place them back-to-back, enough isolation might be achieved to prevent the oscillation.

Unfortunately, separating the donor antennas by a great distance at the San Diego site was not practical, as shown in the above photo.

Two corner reflector antennas placed back-to-back with about 10 feet of separation provide about 65dB of isolation. With the separate donor antennas and the isolation of the two-way splitter, 90dB of attenuation had been achieved. Another 70dB was needed. Filtering was then considered.

A band-specific cellular repeater provides exceptional rolloff at the band edge by the use of down-conversion filtering. As shown in the passband curve graph above, the gain in the uplink of a band-specific BDA is greatly reduced at 851MHz. This will not provide complete relief at 849MHz—but it is a start. Unfortunately it is also *expensive,* and additional filtering will *still* be needed in the downlink of the SMR band repeater to reduce the gain at 849MHz. Even with the additional filtering, the loop gain at 851MHz in this case was 120dB, and the attenuation was only 90dB.

A short discussion with the maintenance technicians revealed
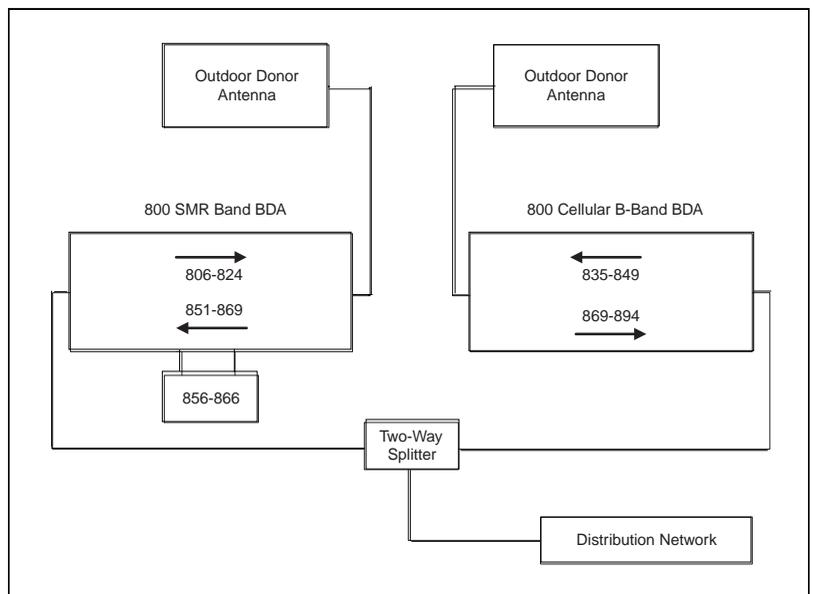
The eight-pole, 10MHz combline filter (tuned to rolloff at 856MHz) was added into the SMR band repeater in the downlink path.
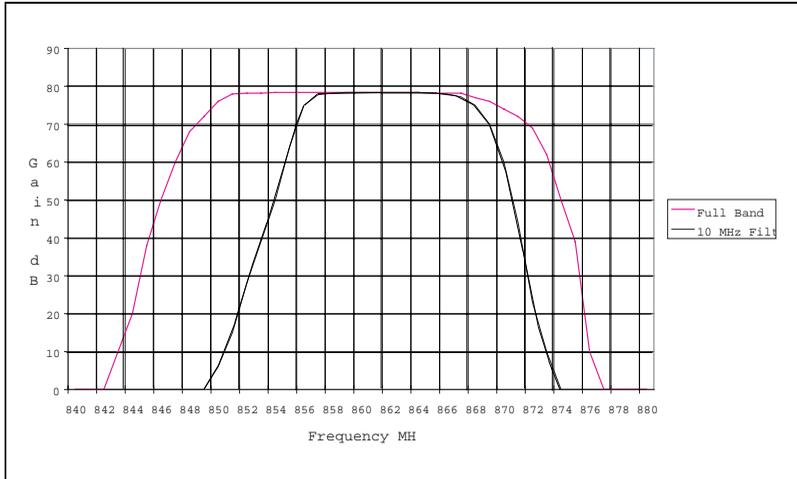
An 800MHz SMR passband with 10MHz filter.

that the operating frequencies of the SMR system were all grouped in a 10MHz band above 856MHz. As such, an eight-pole 10MHz combline filter, tuned to rolloff at 856MHz, could be used to attenuate 849MHz *and* 851MHz.

This filter was added into the SMR band repeater in the downlink path as shown in the block diagram at the bottom of the facing page. The cost of the filter was $200 and, as shown on the passband curve graph at the left, it reduced the gain in the downlink of the SMR BDA to such a level that the more expensive, band-specific, cellular repeater was not needed.

After the filtering, the loop gain was barely above 80dB at 851MHz, and the 90dB of isolation in the system prevented oscillation.

The city of San Diego needed coverage for maintenance workers via the 800MHz SMR radio system. It wanted cellular service as a backup. For the price of a low-cost, cellular BDA and a corner reflector antenna, the city was able to get both services working on the same network.

It is not always this easy to combine 800MHz BDAs on a common network, but it *can* be done. ∎