



VEHICULAR REPEATERS AND THE 700 MHz BAND

Regional planning committees should include vehicular repeater frequencies in their interoperability plans for the 700 MHz band.

By William Carlin



In the trunk of a police car, a 700 MHz vehicular repeater (left) is interfaced to an existing 800 MHz mobile radio. The vehicular repeater provides coverage in areas where the statewide 800 MHz system lacks handheld coverage.

Many public safety agencies currently employ vehicular repeaters to extend the range of their handheld radios; however, many regional planning committees are unaware that rules exist allowing these agencies to continue using conventional analog technology in the newly emerging 700 MHz bands. Proper planning now will ensure that frequencies are available in the band for future interoperability and vehicular repeater use.

In the mid-1990s, the FCC, in an attempt to relieve radio congestion for public safety, decided to reallocate TV channels 60-69 (746-806 MHz) for use as narrowband LMR frequencies. The commission afforded public

safety 24 megahertz of new spectrum, specifically channels 63-64 (764-776 MHz) and 68-69 (794-806 MHz). The proposed plan encouraged the use of spectrum-efficient technologies. This included the utilization of digital modulation techniques incorporated into 6.25-kilohertz and 12.5-kilohertz bandwidth channels.

Realizing that the technology might be several years in development, the FCC mandated a migration path that permitted new 12.5-kilohertz licenses to be granted until Dec. 31, 2005, and existing 12.5-kilohertz systems to operate until Dec. 31, 2015. After the 2005 deadline, any new system licenses would have to employ either dual-

mode or 6.25-kilohertz equipment.

Four factors affect public safety's access to 700 MHz frequencies:

- 1.** The FCC's adoption of the Interoperability Standard (completed January 2001).
- 2.** TV broadcast incumbency, which varies by market.
- 3.** Development of a national 700 MHz frequency plan (completed May 2001).
- 4.** Development of regional 700 MHz frequency plans.

In May 2001, the FCC decided that under the Interoperability Standard, the states should be responsible for the administration of interoperability channels in the 700 MHz



band. While the commission concluded the states were best suited to manage the new spectrum, it recognized that not all states would want the responsibility. If a state elected to develop its own regional frequency plan at 700 MHz, it was required to notify the FCC by Dec. 31, 2001. The FCC also recommended it create a state interoperability executive committee (SIEC) to administer the spectrum. If a state did not notify the FCC of a decision by Dec. 31, 2001, the FCC would create a 700 MHz regional planning committee (RPC) to manage the state's 700 MHz frequencies.



The vehicular repeater's antenna is mounted on the trunk lip to prevent interference from the mobile transmitting antenna mounted on the vehicle's roof.

States that did not respond by the 2001 deadline can still petition the FCC for the rights to administer the 700 MHz spectrum. The only two requirements are a signed letter from the governor indicating the state's desire to create an SIEC and a written

statement from the RPC, if established, agreeing to relinquish the responsibility.

Technical Requirements

Except for mobile and portable transmitters that only operate on designated low-power channels, all transmitters in the 764-776 MHz and 794-806 MHz frequency bands must use digital modulation as a means of encoding voice information to maintain spectrum efficiency. Mobile and portable transmitters may have analog modulation capability only as a secondary mode in addition to the primary digital mode.

Digital modulation is the technique of converting analog signals such as voice into a stream of digital data (1s and 0s) that represents the varying amplitude of the voice, but can be transmitted more efficiently.

Normally, data transmission requires more bandwidth than voice; however, by utilizing data compression techniques in the modulation scheme, higher data rates can be supported in narrower bandwidths.

The Project 25 specification recognizes two modulation bandwidths: 12.5 kilohertz and 6.25 kilohertz per channel. The 12.5-kilohertz channels utilize four-level FM modulation (C4FM), and the 6.25-kilohertz channels use 32QAM modulation.

C4FM modulation compresses data by representing two bits (1s and 0s) for each level of FM modulation. After the analog signal is converted to the digital stream of 1s and 0s, two bits are transmitted at a time, representing four possible states (00, 01, 10, and 11). Each state is assigned to a discrete deviation level (+1.8 kHz for 01, +0.6 kHz for 00, -0.6 kHz for 10, and -1.8 kHz for 11).

In order to get higher data rates into narrower bandwidths, more sophisticated techniques are used. In 32QAM modulation, the analog signal is converted to digital as in C4FM modulation, and each discrete sample is then routed through a lookup table that yields two outputs ("I" and "Q"), each with five possible levels. The "I"

signal is used to AM modulate the carrier, and the "Q" signal AM modulates another carrier 90 degrees out of phase with the first carrier. The two modulated carriers are then combined and transmitted together.

In both types of equipment, analog FM modulation is allowed as a secondary function. Handheld radios designed for use in the 700 MHz band are capable of both digital and analog modulation.

Exception to the Rule

Mobile and portable transmitters that only operate on designated low-power channels are exempt from the digital modulation requirement. Narrowband low-power channels are subject to regional planning.

According to the FCC, the following narrowband channels are designated for low-power use for on-scene incident response purposes using mobiles and portables subject to commission-approved RPC regional plans: channels 1-8 paired with channels 961-968, and channels 949-958 paired with channels 1909-1918. Transmitter power must not exceed 2 watts.

The FCC also designated the following narrowband channels for low-power use for on-scene incident response purposes using mobiles and portables: channels 9-12 paired with channels 969-972, and channels 959-960 paired with channels 1919-1920. These channels are licensed nationwide for itinerate operation. Again, transmitter power must not exceed 2 watts.

So what does this mean? Essentially, there are 36 channels, each 6.25 kilohertz wide, that can be used for on-scene incident response and that do not have to employ digital modulation. These channels can be coordinated by the state's SIEC. There are an additional 12 channels — designated as nationwide itinerate channels — that are also 6.25 kilohertz wide and can be used for the same purpose.





Mobile and portable transmitters may have analog modulation capability only as a secondary mode in addition to the primary digital mode.

Because analog modulation requires channel bandwidths of either 12.5 kilohertz or 25 kilohertz, it would appear that these low-power channels are not suitable for vehicular repeaters using analog modulation. With this in mind, the FCC has given RPCs the authority to combine channels in order to facilitate wider bandwidths.

Combining Channels

In reference to combining channels, the FCC states that contiguous channels may be combined — at the discretion of the appropriate RPC — in order to accommodate requirements for larger bandwidth emissions. As an exception to this general rule, channels designated for nationwide interoperability use must not be combined with channels that are not designated for nationwide interoperability use.

Specifically, the commission states that two or four contiguous narrowband (6.25-kilohertz) channels may be used in combination as 12.5-kilohertz or 25-kilohertz channels, respectively. The lower channel (in frequency) for two-channel combinations must be an odd-numbered channel (in other words, 1, 3, 5).

The lowest channel (in frequency) for four-channel combinations must be a channel whose number is equal to $1+(4 \times N)$, where N equals any integer between 0 and 479, inclusive (for example, channel number 1, 5 ... 1917). Channel combinations are

designated by the lowest and highest channel numbers, separated by a hyphen (for example, "1-2" for a two-channel combination and "1-4" for a four-channel combination).

As a result, there are 18 12.5-kilohertz channels that can be used with low-power analog equipment for on-scene incident response: 1-2, 3-4, 5-6, 7-8, 949-950, 951-952, 953-954, 955-956, 961-962, 963-964, 965-966, 967-968, 1909-1910, 1911-1912, 1913-1914, 1915-1916, and 1917-1918. Furthermore, there are six 12.5-kilohertz channels that are designated as nationwide itinerate channels and which can be used for the same purpose: 9-10, 11-12, 959-960, 969-970, 971-972, and 1919-1920.

It is also important to note that mobile and portable transmitters designed to operate only on designated

low-power channels are exempt from the interoperability channel requirement, which states that all mobile and portable transmitters operating in the 764-776 MHz and 794-806 MHz frequency bands must be capable of operating on all of the designated nationwide narrowband interoperability channels.

As public safety agencies migrate to the new 700 MHz bands, many will discover they still have inadequate portable radio coverage. Fortunately, the FCC had the foresight to allow the states to administrate the regional planning of the 700 MHz spectrum. The FCC rules provide for the implementation of low-power, on-scene response capabilities using analog vehicular repeaters in the 764-776 MHz and 794-806 MHz bands.

Commercially available equipment already exists that operates within the FCC guidelines for 700 MHz spectrum. It is up to each state to coordinate with their regional planning committee to allocate channels for use with these low-power devices. By designating the available channels in their region, or amending their regional plans if already submitted, they can ensure adequate portable radio coverage and interoperability capabilities in the future. ■

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