Analysis of Radio Interference to Client System at... Omitted

Begin excerpt:

Next, Client's representative and 360°RF's engineer travelled to the interference location at the intersection of Generic St. and Unnamed Rd. to observe actual interference with several handheld radios. This site, pictured in ***Figure 2***, is across the street from a large Nextel and Verizon site. ***Figure 1*** shows an aerial view of the site with the cellular tower and reception issue areas marked.

Figure 2, Generic St. at Unnamed Rd. Interference Location, Areal View

Figure 3, Generic St. at Unnamed Rd. Interference Location

Based on prior investigations, Client's representative believes that all of the narrowband carriers from this site are Nextel carriers and the two wideband carriers in the 870MHz range are Verizon. Additionally, Client's representative indicated that during a previous site visit, it was determined that Nextel seemed to be the primary factor in the interference.[1]

The Client's representative and 360°RF's engineer each walked around the parking lot carrying a P7270 portable, occasionally transmitting and receiving and watching the service display on the radios. As seen in ***Figure 1,*** the radio display shows the received signal level and the reported errors on the radio. The table below shows actual receive signal levels reported by the HP 8935 analyzer when connected to a short handheld-style antenna inside of Client's representative's personal vehicle, a Chevrolet Suburban, along with the matching channel designators reported by the P7270 handhelds. These measurements were made on a second trip to the site around 3PM on April 21.

Frequency[2]	Channel	Location	Callsign	RSL, dBm
851.3375	14	omitted	xxxx222	-97
852.2125	49		XXXX910	-97
852.3375	54		XXXX910	-94
852.4125	57		XXXY259	-101
853.1625[3]	87		WQBN222	—
853.3375	94		XXXY259	-103

[1] Our understanding is that combinations of Nextel and Verizon were shut off and on to determine which were the most likely factors in the interference. It was determined that interference was only present with Nextel active and that Verizon had little or no effect on the OpenSky portable radios.

[2] Reported via Excel spreadsheet annex provided by Client. Signals on the channel were verified and measured with the onsite analyzer, HP8935.

[3] 853.1625 was initially believed to be a possible channel in use by the handhelds, but was later found to have analog FM (F3E) voice traffic from a local township. This frequency is reported for completeness but was not used in any tests.

Frequency[2]	Channel	Location	Callsign	RSL, dBm
853.3875	96		XXXZ246	-102
854.4125	137		XXXZ246	-98

Client's representative reported some other findings from previous trips to the site that seemed out of the ordinary and/or significant:

1. The P7200 series handheld radios would not receive interference if attenuators of various sizes were placed between the receiving antenna and the handheld radio. This was also confirmed by a M/A-COM engineer in a conversation with Client's representative. Both reported that the interference was helped or eliminated when an attenuator was placed inline between the radio and antenna.

2. It was reported that the M7200 series mobile radios do not seem to have any interference problems at either this site or another site experiencing interference near a Nextel cellular tower.

3. If a cavity notch filter (attenuation characteristics swept and pictured in ***Figure 4***) is placed between the radio and an antenna, even a directional antenna pointed at the cellular site's antenna array, the interference problem is also eliminated.

4. Since the system was designed to blanket the county with a minimum signal level of -70dBm,[4] and the handheld radios are specified to have a sensitivity of -110dBm,[5] it was believed that there should be a minimum of 40dB signal margin with which to overcome any localized interference issues that might arise.

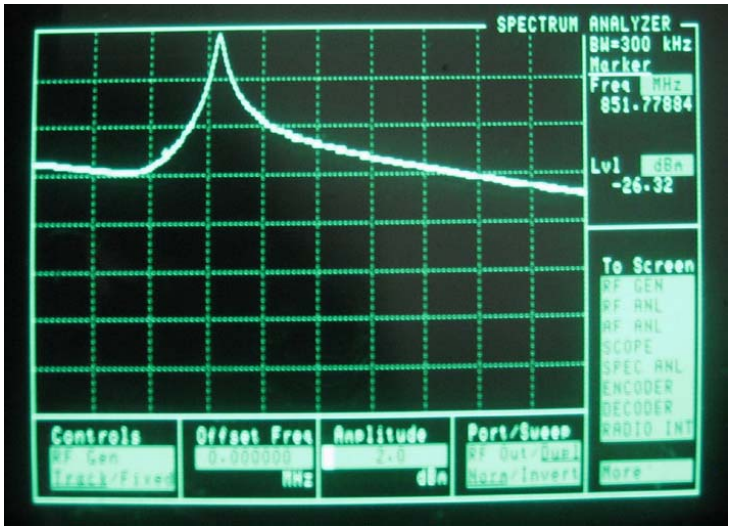

Figure 4, Analyzer plot of 800 MHz cavity used in testing

[4] From conversation with Cliet's staff.

[5] MACOM specifications P7200 series radios, http://www.macom-wireless.com/products/opensky/datasheets/7303.pdf

Additionally, the following facts were uncovered in the investigation that provided supporting information:

1. The P7200 front end provides 20dB of gain from approximately 845-875MHz[6]

2. The P7200 series radio meets TIA-603 radio standards for sensitivity, adjacent channel and intermodulation rejection according to M/A-COM.[7]

3. Client initially tested on 2-slot OpenSky, but is now using exclusively 4-slot OpenSky.[8]

4. A signal level of -112dBm or better is required for recoverable block error rates for 4-slot OpenSky modulation.[9] This is slightly better than the M/A-Com datasheet specification for the P7200 series portables which states that a minimum -110dBm signal is required.

The effectiveness of adding an attenuator pad to the front of the P7200 radio indicates that the interference is most likely due to intermodulation distortion (IMD) products being generated within the handheld radio itself. If intermod products are produced outside of the radio, either in other radios or in a passive manner (PIM), these products would not be eliminated with the cavity test performed previously by Client's representative. This is because the intermodulation products would already be on-channel interference and so would pass through the passband of the cavity since they were produced before they reached the unit under test. Instead, the interference was eliminated. Thus, the probability is very high that the high RF level of all of the Nextel channels at the site is causing the generation of intermodulation products that interfere with desired signals. The most likely cause of this interference is IMD products created within the radio itself.

Since the cavity eliminated the interference, this tends to indicate that the source signals acting as a catalyst for the intermod problem are the Nextel signals, which were attenuated by the steep skirts of the cavity filter. Because the pad between the antenna and the radio also eliminated the interference (by attenuating signals from the antenna), it is highly likely that the intermodulation products are produced within the radio itself. When a pad is connected between the antenna and the input of a receiver, the incoming signals are reduced (or attenuated) by the amount of the attenuator pad.

The most common and problematic IMD products are typically what are called the 3rd-order products, which are produced by mixing two or more signals. These products are created either of several ways, such as:

- by a very strong signal which, because of its high amplitude, causes the generation of a 2nd harmonic which then mixes with second signal, creating a mixing product which frequency is on or very close to the desired signal's frequency; or

[6] Reference omitted, p24

[7] Reference omitted, p8

[8] Reference omitted p2, and discussions with Client's representative

[9] Reference omitted, p27

- by the mixing of three separate signals, one or more of which is strong enough to drive some stage within the receiver into non-linearity, thus allowing the mixing (or combining) of the three signals such that the sum or difference of the signals creates an interfering signal which frequency is on or very close to the desired signal's frequency.

Mathematically, intermodulation products (also known as mixing products) are generated by two frequencies according to the general equation $F_{INT} = mF_1 \pm nF_2$ where m and n are non-zero integers. The order of the product is the sum of the absolute value of the integers m and n.

When the IMD product is generated within a receiver due to pickup from the antenna, the amplitude of the resulting intermodulation products changes by a factor of three. Thus, if a 3 dB pad is inserted between the antenna and receiver, the level of the IMD products decrease by three times this amount, or 9 dB.

If the desired signal is strong enough to allow decoding of the data stream when reduced 3 dB by an attenuator pad, then the reduction of the intermodulation products by 9 dB can provide significant extra margin for the receiver; this appears to have been the case here.

End excerpt.