Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In Re:	)	
	)	
Office of Engineering and Technology	)	
Invites Comments on Technological Advisory	)	ET Docket No. 13-101
Council ("TAC") White Paper and	)	
Recommendations for Improving Receiver	)	
Performance	)	

To: Chief, Office of Engineering and Technology

COMMENTS OF PERICLE COMMUNICATIONS COMPANY

Our company ("Pericle") is a consulting engineering firm specializing in wireless communications. Founded in 1992, Pericle consults for the public safety, personal wireless, transportation and broadcast industries. Through its client, the City and County of Denver, the company was deeply involved in the formulation of the 800 MHz rebanding plan adopted by the FCC in 2004.

Our experience with 800 MHz interference, which is largely a receiver problem, leads us to advocate receiver standards. In particular, we favor an approach that does not mandate the method to achieve receiver robustness but rather defines the environmental limits under which the receiver must operate before it can claim harm and be entitled to protection.

To illustrate the importance of receiver standards, we will share our experience measuring and resolving interference problems in the post-rebanding environment where forward link signals from 862-869 MHz and 869-894 MHz cellular operators can still cause harmful interference.

When the 800 MHz rebanding rules were adopted by the FCC in 2004, certain receiver standards were specified for land mobile radios before such radios were eligible for protection from 800 MHz cellular interference (e.g., from ESMR, cellular A or cellular B). These receiver standards specified performance for 12 dB SINAD sensitivity (-116 dBm), adjacent channel rejection (70 and 75 dB for portables and mobiles, respectively), and intermodulation rejection (also 70 and 75 dB). The implied standard for measurement was TIA-603-B. Because the major source of interference was Sprint Nextel cell sites employing the iDEN airlink standard and all leading manufacturers published these values in their datasheets, the standards made sense at the time. Unfortunately, two problems were overlooked or were considered too difficult to address in 2004.

The first problem involved bandpass filters to be used post-rebanding. The purpose of rebanding was to separate dissimilar services so the near-far problem is manageable. But separation alone does not solve the problem entirely if the receiver front end still passes cellular signals. These strong cellular signals can still cause blocking and intermodulation interference. An essential part of the plan was to eventually install narrower bandpass filters (851-861 MHz) to reject cellular signals, but there was no formal requirement to do so. Unfortunately, manufacturers have been slow to adopt new filters for a variety of practical reasons and in a competitive market there may not be adequate motivation to make this critical change without Government involvement.

The second problem is that the TIA-603-B standard for intermodulation interference is measured with interfering signals in the range of -50 to -45 dBm, but cellular interference on the street is often measured above -20 dBm. Two radios with identical TIA-603-B intermodulation rejection of 70 dB may show dramatically different intermodulation rejection above -50 dBm. This *strong signal intermodulation rejection* never appears on manufacturer data sheets and rarely, if ever, appears in requests for proposal (RFP) for new radio systems.

To better understand the design challenges of the manufacturer when faced with strong signal intermodulation, consider the typical digital receiver shown in Figure 1.

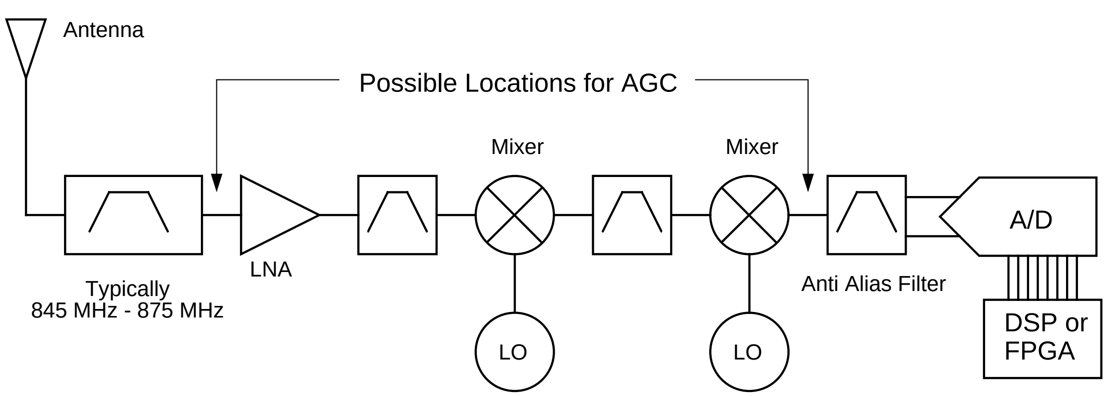

Figure 1 - Typical Modern Digital Receiver

The near-far problem is essentially a dynamic range problem and because the dynamic range of the digital section of the receiver is limited by the number of bits in the A/D, manufacturers typically (but not always) perform a double down conversion prior the A/D. By doing so, the A/D is protected somewhat from harmful signals outside the IF bandwidth. The front end bandpass filter passes the ESMR and much of the cellular A band, so the LNA is often presented with strong signals. The brute force way to fend off intermodulation (IM) interference is to employ an LNA with a high third order intercept (IIP3). Unfortunately, amplifiers with a high IIP3 draw more current and are therefore not practical in battery-operated portable devices.

Automatic gain control (AGC) is another technique to combat strong interferers, but AGC power detectors are usually broadband RF diodes that cannot distinguish between desired and undesired signals. Putting an AGC attenuator in front of the LNA will increase the noise figure of the receiver and thereby desensitize it. A more sophisticated type of AGC might use a second detector at the second IF to detect the amplitude of the desired signal and then apply the right amount of attenuation in front of the LNA to optimize sensitivity of the receiver. This is possible in the case of intermodulation interference because 1 dB of attenuation in front of the LNA attenuates the desired signal by 1 dB, but results in a 3 dB reduction in the 3rd order IM product. Also, because most receivers can tolerate higher levels from blocking than from IM (typically 95 dB versus 75 dB), a receiver that can distinguish between the two types of interference can adapt the AGC accordingly.

In Figure 2 we have plotted the strong signal IM rejection of four radio models from two different manufacturers.[1] In each case, the desired frequency was 851.1750 MHz and the two interfering signals were at 859.6750 and 868.1750 MHz. The performance between radios is dramatically different, but interestingly, all radios employed essentially the same filter which did not roll off until 874 MHz (well inside the cellular A band). Because the third order intercept of the radios can be derived from the TIA-603-B IM rejection which was similar between radios (75-78 dB), we must conclude that other techniques are used in the better performing radios.

Unfortunately for the customer, strong signal intermodulation performance is not specified by the manufacturer and an intelligent comparison is between vendors and models is almost never performed during the acquisition process.

[1]These are actual bench measurements of commercially available public safety radios.

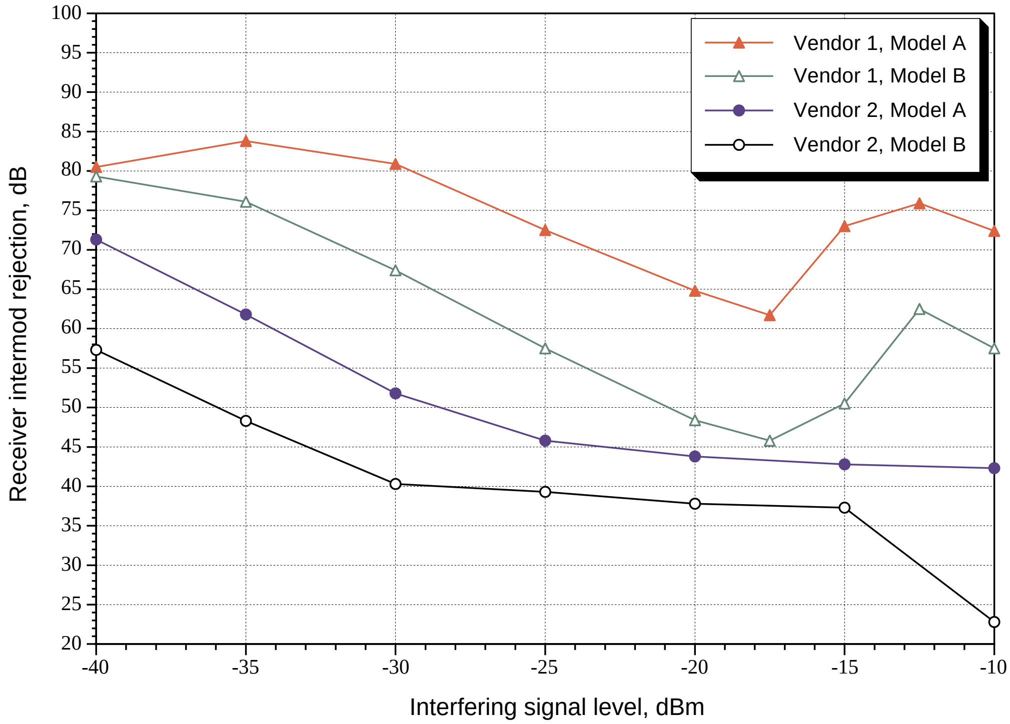

Figure 2 - Strong Signal IM Performance of Several Receivers

At this point, one might ask what are the practical implications of Figure 2? If a public safety agency is using Model A from Vendor 1 and if Sprint Nextel and the cellular A operator are creating two equal power IM interferers at -20 dBm at street level, the desired signal must be at least -20 dBm - 65 dB = -85 dBm to overcome this interference. However, if the same agency is using Model B from Vendor 2, the IM rejection is only 38 dB and the desired signal must be –58 dBm. According to the datasheet, the two radios perform identically, but the real performance difference in a harsh environment does not show on the datasheet.

The significant performance difference with nearly identical bandpass filters illustrates another important principle. If the FCC took a narrow view of the problem, it might specify a minimum filter rejection as the receiver standard. But this approach would miss the point and possibly stifle innovation. What matters is the strong signal IM rejection. We don't care how it is achieved. It might be a filter or it might be a novel AGC algorithm or some other innovation. Clearly, Vendor 1 found a way to improve performance without a better filter. That said, better bandpass filters post-rebanding are still desirable and an important first step.

Many of the older measurement standards such as TIA-603-D (the most current version) assume signals with continuous phase modulation (e.g., FM) and a peak-to-average ratio of 1. In practice, cellular signals such as UMTS and LTE have high to peak-to-average ratios. The semiconductors in the receiver will likely react to peak power, not average power, when IM products are created, so the peak-to-average power ratio must be considered when specifying both the environment and the method to test for compliance.

In light of the preceding facts and observations, we make the following recommendations:

1. The FCC should define the environment in which the receiver must operate before it is entitled to protection, not the particular method used to achieve this performance in the receiver.

2. Test methods to prove compliance must be adopted and current measurement standards may not be adequate. For example, peak power of the interfering signal must be considered, not just average power.

3. Once receiver standards are adopted, manufacturers should label their products to indicate compliance. An informed buyer encourages competition and ultimately improves quality.

4. Manufacturers should voluntarily expand their data sheets to show measurement results that are relevant to the environment in which the receiver will operate, such as strong signal intermodulation rejection.

Respectfully submitted, **PERICLE COMMUNICATIONS COMPANY**

By

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