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ATTORNEYS AT LAW

July 31, 2008

Ex Parte

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186

Dear Ms. Dortch:

The White Spaces Coalition[1] has observed throughout this proceeding that spectrum sensing technology will protect wireless microphone operations in the TV bands. However, the Coalition has also recently agreed to support a requirement that white space devices detect a wireless microphone beacon with certain properties if doing so would assist the Commission in moving forward with final operating rules.[2] While the Coalition's previous filing included technical parameters for beacons using a pseudorandom sequence, the Coalition also recognizes that the Commission may wish to consider a simpler, multitone beacon requirement. Accordingly, the Coalition offers some thoughts on this approach as well.

The simplest beacon to implement is probably a single, continuous radio carrier (or tone) broadcast at a specific frequency. However, even a nominally vacant TV channel frequently contains spurious signals that could be mistaken for this type of beacon, which would erroneously indicate that a TV channel is occupied. Thus, any beacon approach should transmit a pattern – that is, a signature – that is easy to detect and is unlikely to be confused with spurious signals. Pseudorandom sequences, such as those previously proposed by the Coalition and others, can be used for this purpose.[3] To be effective, however, these approaches require some form of synchronization between the white space device and the beacon, which can add to complexity and increase detection times in harsh environments.

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[1] The White Spaces Coalition's members include Dell, Inc., Google, Inc., Hewlett-Packard Co., Microsoft Corp., Palm, Inc., Philips Electronics North America Corp., and TDK Corp.

[2] *See generally* letter from Edmond Thomas, Senior Technology Policy Advisor to Marlene H. Dortch, ET Doc. No. 04-186 (filed June 17, 2008).

[3] *See, e.g., id.*; Z. Lei and F. Chin, "A Reliable and Power Efficient Beacon Structure for Cognitive Radio Systems," IEEE Transactions on Broadcasting, Vol. 54 No. 2, at 182-187 (June 2008); E. Callaway *et al.*, "Motorola Beacon Proposal, A Proposal for the 802.22.1 Standard," Doc: 22-06-0128-01-0001 (Sept. 2006).

One approach that provides an easily distinguishable pattern that can be detected with high reliability is to employ a beacon consisting of two or more continuous tones with known frequency separation. Multiple tones dramatically reduce the probability of false alarms. We describe a laboratory proof of concept for this beacon design in greater detail below.

For the proof of concept, the beacon signal, consisting of a pair of CW tones centered at 600 MHz and separated by 50 KHz, is input to a cognitive radio programmed to calculate a 1024-point discrete Fourier transform (DFT) of a 4-msec segment of the beacon signal. The 1024 Fourier "bins," each 250 Hz wide, are searched for a pair of "hits" with the required 50 KHz separation. Figure 1 illustrates the beacon signal setup.

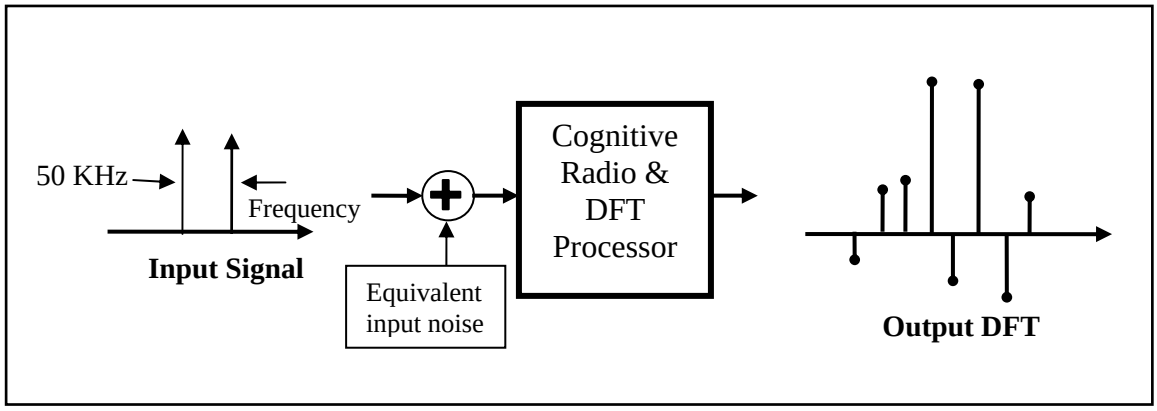

Figure 1. Experimental Beacon

Figure 2 shows the probability of missed detection (Pmd) as a function of total input beacon power (sum of both tones), with the detection threshold set for a 1% probability of false alarm. The power required for Pmd = 1% is -125 dBm, which compares favorably with the threshold of -107 dBm proposed for wireless microphone detection by the IEEE 802.22 Committee.[4]

[4] *See* C. Cordeiro, K. Challapali and D. Birru, "IEEE 802.22: An Introduction to the First Wireless Standard based on Cognitive Radios," Journal of Communications, Vol. 1, No.1, at 38-47 (Apr. 2006).

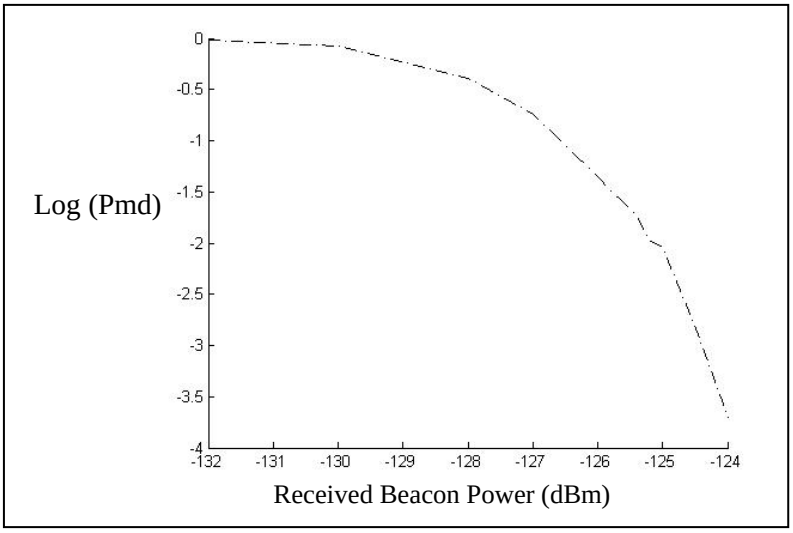

Figure 2. Beacon Detection Performance

The key advantages of this beacon are:

1. Simplicity. A Digital Signal Processor (DSP) can be used to generate the tones for the beacon signal. It allows any number of tones to be placed at whatever frequencies are desired. The detector is based on a conventional DFT processor – essentially the same technology used in orthogonal frequency division multiplex (OFDM) systems such as 802.11a wireless LANs. The continuous nature of the beacon means that no synchronization is required.

2. Robustness against false alarms. If two tones do not provide adequate protection against false alarms, more tones can be used. The probability of a false alarm decreases rapidly (approximately exponentially) with the number of tones transmitted.

3. Relaxed frequency stability requirement. The precise beacon center frequency is unimportant, as long as it lies within the range of the DFT processor. The requisite frequency stability is easily realizable with current technology.

4. Sensitivity. Narrow Fourier bin widths (*i.e.* long integration times) are possible because the carrier drift during an observation period (4 msec in the case above) is negligible.

5. Robustness against multipath. In a multipath (*i.e.* frequency-selective) fading environment, the probability of missed detection due to a frequency-selective fade can be minimized by using three or more tones, spread across the full width of the TV channel being protected.

6. Minimal spectral occupancy. Even if several widely spaced tones are used, the actual bandwidth occupied by the Fourier bins, and therefore unavailable for actual communications, is extremely small.

Our experimental data indicate that this design approach provides a beacon that can be reliably detected and easily and economically implemented. The design may be employed in many applications where cognitive radios are utilized, including the detection of wireless microphones.

Pursuant to the Commission's rules, a copy of this notice is being filed electronically in the above-referenced docket. If you require any additional information please contact the undersigned.

Sincerely yours,

Edmond J. Thomas
Senior Technology Policy Advisor

cc: Julius Knapp, Chief, Office of Engineering and Technology