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Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Interpretation of Occupied Bandwidth as applied to CFR47 Part 15 §247

Dear Sir or Madam,

SignalCraft Technologies Inc. would like to apply hereby for FCC approval of the interpretation of the 20-dB occupied bandwidth, described hereinafter as the "power bandwidth", in compliance with CFR 47 Part 15 §247 Section (a)(1)(i) related to frequency hopping spread spectrum systems operating in the non-licensed bands, which mandates that "*The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz*".
We understand that the intent of this rule is to avoid excessive levels of radio frequency power in the immediately adjacent channels in order not to cause interference to the communication links that may be established in those channels, given that there are no adjacent noise requirements applicable to the channels inside the non-licensed bands. This naturally conjugates with the requirement of Part 15 §247 Section (d): "*In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power…*".
Considering that CFR 47 Part 15 §247 Section (a)(1)(i) does not provide for an exact definition of the "20 dB bandwidth ", nor a specific measurement methodic is given, the occupied bandwidth notion may be open to various interpretations suitable to

compliance demonstration. FCC Public Notice DA 00-705 "Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems" in its "20 dB Bandwidth" paragraph advises that the delta-marker approach be used, whereby a reference marker is set to the peak of the emission and another marker is moved successively to -20 dB points on both sides of the peak to find the difference between the two markers, thus effectively measuring the envelope of the emission as presented by a spectrum analyzer with a particular resolution bandwidth. This approach is referred to hereinafter as the "envelope bandwidth". The same Notice admits in its preamble that "*The FCC has no established test procedure for frequency hopping spread spectrum devices. Such tests are to be performed following the general guidance in Section 15.31 of the FCC Rules, using good engineering practice.*"

We posit that the "envelope bandwidth" approach is deficient in describing immunity of the adjacent channels comprehensively, as defining the occupied bandwidth by a level of the envelope roll-off misses the factor of the signal spectral shape and hence it is not universally interchangeable between different modulation formats, that is, differently modulated signals will produce different amounts of adjacent channel interference for the same magnitude of envelope change between the peak and a particular point on the envelope. This would not be as problematic if a separate adjacent noise requirement existed for the channels inside the non-licensed bands. Since it is not the case, the occupied bandwidth requirement is to bear the brunt of preventing excessive interference in the adjacent channels. Considering that communication signals are inherently bandwidth-limited, a more comprehensive approach is to define the occupied bandwidth by the relative amount of signal power contained within defined frequency limits. For example, if a particular frequency band contains 99% of signal power, the remaining 1% fraction, which is 20 dB below the channel power, lies outside. We call this approach the "99% power bandwidth". There is a degree of correlation between the "envelope bandwidth" and the "power bandwidth" approaches, but we posit that the latter is more comprehensive and proper in assuring the spectral compactness of a tested channel. Indeed, consider a signal spectrally shaped by the Gaussian function of the following general form:

$$y = Ae^{-\frac{1}{2}\left(\frac{x}{\sigma}\right)^2} \tag{1}$$

whose width may be expressed in multiples of Gaussian standard deviation, $z\sigma$, where z is a real constant. Then the percentage of power constrained in a *($-z\sigma$, $+z\sigma$)* band can be calculated using

$$P_{\%} = 100 * \operatorname{erf}\left(\frac{z}{\sqrt{2}}\right) \tag{2}$$

where *erf* is the Gaussian error function. Constant *z* for a particular power ratio is found by taking inverse of (2). For P = 99%, z is equal to 2.576. Relative envelope level corresponding to a particular offset $z\sigma$ may be found in dB with respect to the peak using

$$R = 20\log\left[\frac{Ae^{-\frac{1}{2}\left(\frac{x_{meas}}{\sigma}\right)^2}}{Ae^{-\frac{1}{2}\left(\frac{x_{peak}}{\sigma}\right)^2}}\right] = 20\log\left[\frac{Ae^{-\frac{1}{2}\left(\frac{z\sigma}{\sigma}\right)^2}}{Ae^{-\frac{1}{2}\left(\frac{0}{\sigma}\right)^2}}\right] = -4.34 * z^2 \ (dB) \tag{3}$$

Therefore, 99% of power of the given signal is contained between the *(-2.576σ, $+2.576\sigma$)* limit, by which the envelope rolls of by $-4.34*2.576^2$ = 29 dB. The 20-dB bandwidth of the same signal is calculated using (3) as *(-2.15σ, $+2.15\sigma$)*, which contains 96.8% of signal power, with 3.2% spilling outside. Hence, the adjacent channels are -14.9 dBc, which is 5.1 dB higher then with the 99% power bandwidth definition!
Certainly, a reverse situation is also possible depending on the spectral shape when the 99% power bandwidth may be narrower than the 20-dB envelope bandwidth, but that is definitely less harmful to the adjacent channels, as a known majority of signal power remains inside the channel.

We seek hereby your confirmation that the 99% power bandwidth is a valid interpretation of the 20 dB bandwidth in proving communication apparatus compliance with CFR 47 Part 15 §247 Section (a)(1)(i).

Sincerely Yours,

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