Annex B – Response to FCC Comments – Correspondence Reference number 16053

Harmonix FCC ID O2900000-30-30
Report Number J20013614

The following information is submitted pursuant to requests from the FCC for further information, Correspondence Reference number 16053.

This annex describes the methodology defined by Harmonix for determining the allowable maximum power of the subject radio. The test results presented were obtained at Site 2C, Intertek Testing Services – ETL/SEMKO, Boxborough, MA on 9/20/00.

======================= RESPONSE TO 16053 ==========================
As shown below, the equipment under test (EUT) FCC ID# O2700000-30-30 qualifies as a broadband radio under Section 15.255(e)(1), and the applicable peak power limit is 500 mW.

47 CFR Chapter 1 Part 15.255 (e) 1 states "emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer".

The emission bandwidth for EUT is 311.04 MHz, since there are at least two spikes only –5dB from peak somewhere between ±155.52 MHz from the carrier in any given moment. Therefore, the emission bandwidth is greater than 100MHz. The applicable limit should be 500mW.

Following are the theoretical reasoning and quantitative analysis as well as the results of additional measurements made at Intertek Testing Services on September 20, 2000. These present more detailed spectrum measurements to illustrate actual "Emission Bandwidth" defined in the Part15.255 (e).

Theoretical Reasoning and Quantitative Estimate

Unlike traditional analog modulation, digital pulse modulation is much more dynamic in its behavior. The spectrum changes rapidly from instant to instant under control of the data stream. The plot previously submitted with the test report shows the emissions profiles of 2^{23}-1 pseudo-random numbers averaged over time. Under these conditions, the modulation products (spikes) are evenly distributed over the information bandwidth. Because the spikes occur only rarely at any specific frequency, the plot appears to be empty within 12 dB of the peak. But this is an artifact of time averaging. In fact, the region below -2 dB is occupied at every instant with spikes flickering from one frequency to another.

These spikes are due to the fact that any pulse train can be described as a square wave with duration of *wp*. where *w* is angular frequency.

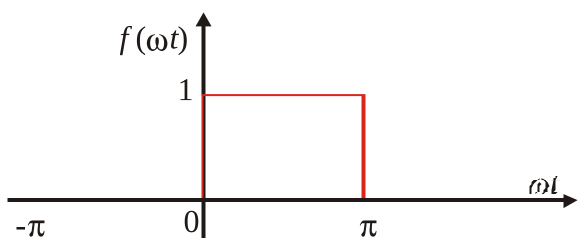

Figure 1.

$$f(\omega t) = \begin{cases} 0, & \text{for } -\pi < \omega t < 0, \\ 1, & \text{for } 0 < \omega t < \pi. \end{cases} \qquad \text{Eq. 1}$$

This square wave function of Eq. 1 yields Fourier series components.

$$f(\omega t) = \sum^{n} \frac{2}{n\pi} \sin(n\,\omega t) \qquad \text{Eq. 2}$$

where n is odd integer

The significant information is contained in the first order where n = 1.There should be two spikes of the first order ($n = \pm 1$) of -1.96 dB Fourier coefficient (for unity modulation: modulation and carrier energy is equally distributed) from the peak that exist at the data sequence recursive frequency from the CW. When the pseudo-random data is transmitted, as in the plot submitted with our application, these spikes are smeared by averaging and buried in the sea of following data sequences. Part 15.255 (e)(1) defines bandwidth in terms of <u>the instantaneous frequency range.</u> The first order spikes are the primary modulation products. The second order spikes and beyond can be discarded as spurious.

For OC-3 (155.52 Mbps), spikes appear throughout the range up to ±155.52 MHz from the carrier. For OC-12 (622.08 Mbps), it is true for all the way up to ±622.08 MHz from the carrier. For 100BASE-FX (125 Mbps), it is true throughout the range up to ±125 MHz from the carrier. The outside of this bandwidth is filtered for better S/N, see block diagram.

Laboratory Measurements
The spikes are easier to see when the transmitted data follows a repetitive pattern. For example, Figure 4 shows the spectrum of a repeated sequence consisting of 2 zeros alternating with 2 ones. Predicted quantities are –1.96 dB at 77.76 MHz away from the peak. The –2.10 dB spikes are observed at 78.1 MHz away from the peak, for a total emission bandwidth of more than 100 MHz. In the same way, an irregular data stream will place spikes at every frequency out to +/- 155.52 MHz.

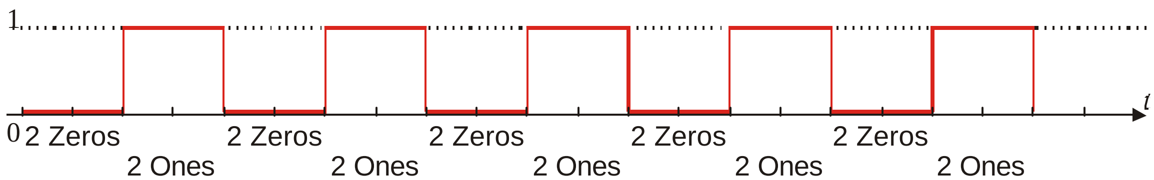

Figure 3.

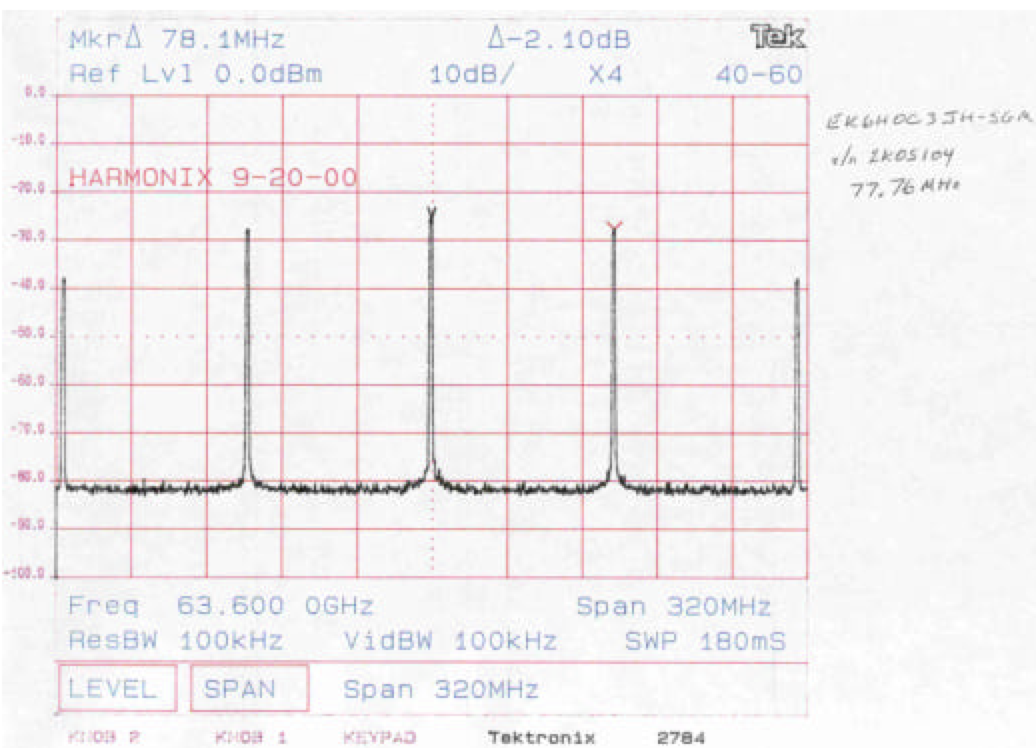

Figure 4.

Therefore, the applicable limit should be 500mW.