HXI-response to 15550 -000811.doc

Re: FCC ID O2700000-30-30
Applicant: Harmonix Corporation
Correspondence Reference Number: 15550
731 Confirmation Number: EA97821
Date of Original E-Mail: 08/11/2000

1) The confidential letter letter lists only the block diagram, schematics and the operational description. It appears that you also want only PCB photo's submitted with the schematics confidential. Please verify, as internal photo's elsewhere in the filing such as in the test report were submitted.

[RESPONSE BY Harmonix Corporation]

Confirmed. The internal photos you find elsewhere are not confidential because anyone with the proper tools could obtain this view without destroying the product. The PCB photos submitted with the schematics, however, must be kept confidential. In summary, the confidential items are

[ITEM 1] **The schematics file**, which contains the PCB photos and the schematics

[ITEM 2] **The block diagram file**, which contains the block diagram

[ITEM 3**] The operational description file**, which contains the detailed description.

We confirm that three items listed above are confidential.

2 Due to the modulation type, please verify that the peak to average factor is 3 dB.

[RESPONSE BY Harmonix Corporation]

The peak to average factor should be considered as 4 dB.
The 3 dB figure may be a reasonable initial guess factor. However, for both the measurement (See the tables on pages 27-30, Harmonix_rev_7_28.doc.) and the analysis (See the second paragraph on page 4, HXI-Detailed Description of Operation-000802.doc.), the peak to average factor of 4 dB represents the worst case scenario in a real world situation, however, either 3 dB or 4 dB yields a qualified numbers.

2) As a result from the MPE RF Safety exhibits there is a discrepancy in the gain of the antennas. The MPE exhibits indicate that the Gain of the patch is 28 dBi and the Gain of the Parabola is 43 dBi. The test report indicates that the patch has a Gain of 30 dBi and the Parabola is 38-39 dBi. What is the correct gain of each antenna?

[RESPONSE BY Harmonix Corporation]

All of these numbers are correct gain figures. There is no direct method to measure high gain antenna in this frequency since we always have to factor in other variables such as oxygen absorption. The discrepancy of the above mentioned numbers arises from the method of estimating the antenna gain for the worst case. Furthermore, we have no control over what InterTek Testing Service, Inc. writes in order to preserve the integrity of their attestation statement. First, the gain numbers appearing in Table 1of the MPE exhibits are based on Equation 15 of page 28, OET Bulletin 65, Edition 97-01, which are the theoretical worst case numbers. 29 dBi was derived based on the theoretical aperture efficiency η =0.28, which is calculated for a 3 " x 5 " 748 element patch array based on pages 7-24 of the *Antenna Engineering Handbook* by Richard C. Johnson and Henry Jasik, (1961, McGraw-Hill, ISBN 0-07-

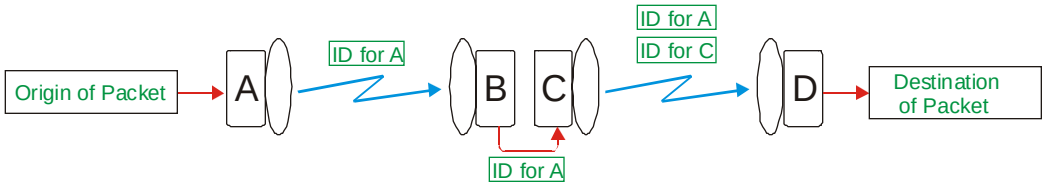
032291-0). The parabola gain of 43 dBi was derived based on the theoretical aperture efficiency η =0.49, which is calculated for 13" (66λ) diameter Cassegrain based on pages 17-34, 36-4 of the *Antenna Engineering Handbook*.
Secondly, the InterTek antenna factors are based on actual measurements with adjustments performed with a near-field effect and a sub-reflector shadow of the Cassegrain antenna. In each case, we did not object to these numbers since these numbers are used as pessimistic figures, i.e. total output power calculation shows higher than actual number if one opts to use lower than actual transmitter antenna gain figure. Substituting these numbers interchangeably, still meet the requirements.
We feel comfortable stating the numbers at somewhere in between, 29 dBi for the patch array and 40 dBi for the Cassegrain antenna in the "published specifications". In other words, the Lab measurements of our laboratory agree with these figures.

3) With regard to the operation in the public coordination channel, you provided plots with OC3 modulation and indicated that the lowest center frequency will be 59.210 GHz. You did not show compliance with OC12 modulation which is a much wider emission. Show compliance with OC12 modulation and indicate the center frequency of the lowest channel for this modulation.

[RESPONSE BY Harmonix Corporation]
59.210 GHz CW unit is not scheduled with OC-12 Optics. An OC-12 interface must be set up at a factory with an OC-12 specific optical transceiver. The lowest and highest CW frequency for an OC-12 radio in the United States is 59.6812 GHz and 63.0090GHz. Please refer to Table 1 on page 2 of HXI-Detailed Description of Operation-000802.doc.

4) FYI_With regard to Section 15.255(i), you state that the serial number was not required but the waiver requested was not necessary because you requested the same serial number for multiple transmitters rather than a unique serial number for each transmitter. I sent an intepretation letter to the downtown office to clarify. But I believe that a serial number is required.

[RESPONSE BY Harmonix Corporation]
The product's unique serial number is implemented in the ID packet (see Datagram description "4th row" of the Packet Diagram on page 3, HXI-Detailed Description of Operation-000802.doc). The waiver is necessary because if the radios were deployed in the multiple link (more than one link) within a local area network, a radio could receive another radio's serial number and then retransmit this number. The retransmission is used to monitor the health of all the radios within the network. If tables, diagrams and equations do not show in this documents, please refer to "HXI-RESPONSE to 15550 -000811.doc" in cover letter category.



5) The peak output power measurement and power density measurements were based on measurements with the Patch antenna. However, you did not provide measurements with the Parabola antenna which from previous data shows that it is worst case and is close to the limits. Provide measurements with the Parabola antenna. For peak output power measurements use a CW signal, measure the power received at 3 meters and use the Friis equation.

P(transmitter)= P(total received)/(GrGt((4*Pi*r)/lambda)^2) where Gr is the gain of the receiver, Gt is the gain of the transmitter, Pi= 3.14159, r = 3 meters and lambda = 300/Frequency(MHz).

Peak power density(PSD) is then
PSD= P(transmitter in dbm)* Gt/(4*Pi*r)^2 .
The Average power density becomes Average PSD=Peak Power density(PSD) - 3 dB(duty factor).

[RESPONSE BY Harmonix Corporation]

We apologize for the confusion relating to the previously up-loaded files.

The peak power density measurements were performed for three different frequencies for the systems with patch array antenna, two frequencies for the system with a parabola antenna. The results were listed and marked as pk in Table 1 and 2 of Page 27 and page 38 of Harmonix_rev_7_28.doc. The measurements were performed on continuous carrier wave (CW or continuous high state), see the first paragraph of page 39 of Harmonix_rev_7_28.doc.

The sample calculation for the total transmitted power was not performed for parabola since the gain of parabola antenna is in the order of magnitude larger, so, probably ITS thought it was obvious and did not list the calculation. If tables, diagrams and equations do not show in the following pages, please refer to "HXI-RESPONSE to 15550 -000811.doc" and "HXI-statement of equivalency -0008111.doc" in cover letter category and "HXI-revised Table 1 and 2 -0008111.xls" in test report category.

The Statement of Equivalency

The Part 15.255 (b) (1) "For products other than fixed field disturbance sensors, the average power density of any emission, measured during the transmit interval, shall not exceed 9 μW/cm^2, as measured 3 meters from the radiating structure, and the peak power density of any emission shall not exceed 18 μW/cm^2, as measured 3 meters from the radiating structure." explicitly states to measure the power density at 3 meters away. Therefore, the method used in the test report produced by InterTek Testing Service faithfully follows the rule.

The equation you have provided is the basis of the test report. The fundamental relationship known as the free-space or Friis equation may be written as

$$\frac{P_R}{P_T} = G_T G_R \left[\frac{\lambda}{4\pi d}\right]^2 \quad \text{..... (Eq.1)}$$

where L_p is the path loss at distance d = 300 cm. P_T is the power supplied to the transmitting antenna with a gain of G_T in the direction of the receiving antenna. P_R is the power at the receiving antenna of gain G_R. λ =0.5 cm is the wavelength of propagation. Assumption is reflection-matched, polarization-matched, aligned for maximum reception.

Thus far, we are in agreement.

The power density is defined as a total power at an unit area of the spherical surface of the isotropic radiation front, and *EIRP* is defined as $P_T G_T$, thus,

$$P_{SD} = EIRP / (4\pi d^2) = P_T G_T / (4\pi d^2) \quad \text{..... (Eq.2)}$$

$$P_T = P_{SD} (4\pi d^2) / G_T \quad \text{..... (Eq.3)}$$

The total output power in logarithmic(dB) format;

$$P_{T(\mathrm{dB})} = P_{SD\,(\mathrm{dB})} + 10 \log (4\pi d^2) - G_{T\,(\mathrm{dB})} \quad \text{..... (Eq.4)}$$

The total output power evaluation can be done in absolutely the worst case. Let us assume that the radio with a 13 inch Parabola has a power density as much as the rules permits, which is P_{SD} = 18 μW/cm^2 at 3 meters away. This can be converted into EIRP of 20.35 W or 43.08 dBm. The only unknown in this figure is the transmitter antenna gain G_T. According to Eq.4 above, larger and more efficient antenna minimizes the total output power of the radio. Within the given worst-case antennae gain 37 dBi yields the total output power is equal to 6.08 dBm or 4 mW. The 43 dBi antennae gain suggested by the calculation based on the Bulletin 65, yields 0.08dBm or 1.02 mW. The limit of the total output is 500mW or 27 dBm.

Therefore, the total peak power out does not exceed the required by Part 15.255(e).

While Eq.1 and 2 together and λ =0.5 cm yields

$$P_{SD} = P_T G_T / (4\pi d^2) = 4\pi P_R / (G_R \lambda^2) = 16\pi P_R / G_R \quad \text{..... (Eq.5)}$$

In logarithmic(dB) format;

$$P_{SD\,(\mathrm{dB})} = 10 \log 16\pi + P_{R\,(\mathrm{dB})} - G_{R\,(\mathrm{dB})} \quad \text{..... (Eq.6)}$$

Power density is measured as received power at 3 meters with calibrated instruments such as the standard gain antenna and power meters. The test report further elaborates this equation by introducing corrections such as a correction factor for their receiver mixer, line loss caused by the cable, etc. Eq. 6 becomes;

$$P_{SD\,(\mathrm{dB})} = P_{R\,(\mathrm{dB})} + (10 \log 16\pi - G_{R\,(\mathrm{dB})})$$

$$= (P_{Reading\,(\mathrm{dB})} + L_{\mathrm{Cable}\,(\mathrm{dB})} + L_{\mathrm{Mixer}\,(\mathrm{dB})}) + F_{\mathrm{Antenna}\,(\mathrm{dB})} \quad \text{..... (Eq.7)}$$

where $P_{Reading}$ is the actual power reading at the receiver instruments in dB, L_{Cable} is the actual power reading at the receiver instruments in dB, L_{Mixer} is the Mixer loss of the receiver instruments in dB, F_{Antenna} is the antenna factor of the receiver instruments in dB, which is defined as $4\pi / (G_R \lambda^2)$.

This is equivalent to your suggestion since it is derived from the same formula.

For example, power density of the High Channel Unit with a Parabola Antenna is the worst case, see fourth row from the end of the Table 2. $P_{Reading\,(\mathrm{dB})}$, the CW reading of the field strength was 64.5 dB μV/m @63.597860 GHz, the Antenna Factor: $F_{\mathrm{Antenna}\,(\mathrm{dB})}$ is 41.3 dB, the Cable loss: L_{Cable} is 0.8 dB, the Mixer loss: L_{Mixer} is 24.0 dB. Thus, $P_{SD\,(\mathrm{dB})}$ is 138.0 dB μV/m.

Conversion from μV/m to mW/cm^2 is given by the Equation (1) of OET Bulletin 65.

$$P_{SD}(\mathrm{mW/cm^2}) = \mathrm{E}^2(\mathrm{V/m}) / 3770 \quad \text{.....(Eq.8)}$$

Since dB V/m converts to power in dB = 20 log E,

$$P_{SD}(\mathrm{mW/cm^2}) = (10^{(138/20)} \times 10^{-6})^2 / 3770 = 16.736\ \mu\mathrm{W/cm^2}$$

We noticed that the tables in the test report have confusing labels. According to the page 26 of the test report, the table should be labeled as follows.

X - Data Tables Revise Label by Harmonix Corporation.

Radiated Emissions / Interference

Table: 1

Company: **Harmonix**
Model: **Patch Array - SGM**
Job No.: **J20013614**
av = average
pk = peak
Date: 05/24/00
Standard: FCC Part 15, 15.255
Class: None Group: None
Notes: RBW=1MHz, VBW=7MHz

Tested by: Michael Peters
Location: Site 3C
Detector: TEK 2784
Antenna: Mixer+Horn (33-200)GHz
PreAmp: None
Cable(s): 1.5 m High Frequency
Distance: **3.000** meters

	Ant. Pol. (V/H)	Frequency MHz	Reading dB µV/m	Antenna Factor dB	Cable Loss dB	Mixer Factor dB	Net dB µV/m	Net µW/cm^2	Limit µW/cm^2	Pass/ Fail
	MID Channel									
av	H	61380.090	61.4	40.945	0.8	23.0	126.1	1.092	9.0	
pk	H	61380.090	64.7	40.9	0.8	23.0	129.4	2.334	18.0	Pass
	H	61224.630	34.6	40.9	0.8	23.0	99.3	0.002	9.0	Pass
	H	61069.160	34.2	40.9	0.8	23.0	98.9	0.002	9.0	Pass
	H	61516.500	-----	41.0	0.8	23.0			9.0	Pass
	H	61540.000	37.6	41.0	0.8	23.0	102.4	0.005	9.0	Pass
	H	60913.450	26.0	40.9	0.8	23.0	90.7	0.000	9.0	Pass
	LOW Channel									
av	H	59162.060	63.7	40.6	0.8	22.0	127.1	1.368	9.0	Pass
pk	H	59162.060	67.9	40.6	0.8	22.0	131.3	3.599	18.0	Pass
	H	59010.000	34.8	40.6	0.8	22.0	98.2	0.002	9.0	Pass
	H	59321.000	35.6	40.6	0.8	23.0	99.0	0.002	9.0	Pass
	HIGH Channel									
av	H	63597.860	59.7	41.3	0.8	24.0	125.8	0.998	9.0	Pass
pk	H	63597.860	64.5	41.3	0.8	24.0	130.6	3.013	18.0	Pass
	H	63573.140	32.2	41.2	0.8	24.0	98.3	0.002	9.0	Pass
	H	63442.300	33.4	41.2	0.8	24.0	99.4	0.002	9.0	Pass
	no emissions other than the fundamental were detected above 40GHz									

Radiated Emissions / Interference

Table: 2

Company: **Harmonix**
Model: **Parabolic Antenna - SGM**
Job No.: **J20013614**
av = average
pk = peak
Date: 05/25/00
Standard: FCC Part 15, 15.255
Class: None Group: None
Notes: RBW=1MHz, VBW=7MHz

Tested by: Michael Peters
Location: Site 3C
Detector: TEK 2784
Antenna: Mixer+Horn (33-200)GHz
PreAmp: None
Cable(s): 1.5 m High Frequency
Distance: **3.000** meters

	Ant. Pol. (V/H)	Frequency MHz	Reading dB µV/m	Antenna Factor dB	Cable Loss dB	Mixer Factor dB	Net dB µV/m	Net µW/cm^2	Limit µW/cm^2	Pass/ Fail
	HIGH Channel									
	V	62024.000	-----	41.0	0.8	23.0				
av	V	61842.220	68.8	41.0	0.8	23.0	133.6	6.090	9.0	Pass
pk	V	61842.220	73.0	41.0	0.8	23.0	137.8	16.019	18.0	Pass
	V	62464.100	45.0	41.1	0.8	23.0	109.9	0.026	9.0	Pass
	V	61220.100	45.4	40.9	0.8	23.0	110.1	0.027	9.0	Pass
	LOW Channel									
av	V	59845.700	70.5	40.7	0.8	22.0	134.0	6.701	9.0	Pass
pk	V	59845.700	74.5	40.7	0.8	22.0	138.0	16.736	18.0	Pass
	V	60467.560	50.0	40.8	0.8	22.0	113.6	0.061	9.0	Pass
	V	59223.350	48.8	40.6	0.8	22.0	112.2	0.044	9.0	Pass
	no emissions other than the fundamental were detected above 40GHz									