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April 10, 2000

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OFFICE OF THE SECRETARY

BY HAND DELIVERY
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Federal Communications Commission
445 12th Street SW
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Re: ET Docket No. 99-231,
Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices
— Ex Parte Filing

Dear Ms. Salas:

Pursuant to Section 1.1206(a)(2) of the Commission's Rules, I am filing the original and one copy of this letter to report an oral ex parte communication in the above-referenced proceeding.

This morning Jim Zyren of Intersil Corporation, Donald C. Johnson and Susan E. McNeil, Esq., of Lucent Technologies, and the undersigned met with Julius Knapp, Karen Rackley, and Neal McNeil of the Office of Engineering and Technology.

Meeting participants presented and discussed the substance of the attached paper, which is intended as a compromise proposal to resolve differences among parties to the proceeding.

Kindly date-stamp and return the extra copy of this letter.

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If there are any questions about this filing, please call me at the number above.

Respectfully submitted,

Mitchell Lazarus
Counsel for the Wireless Ethernet Compatibility Alliance

ML:deb

Enclosure

cc: Meeting Participants (By Hand Delivery or US Mail)
Commissioner William E. Kennard (By Hand Delivery)
Commissioner Harold Furchtgott-Roth (By Hand Delivery)
Commissioner Michael Powell (By Hand Delivery)
Commissioner Susan Ness (By Hand Delivery)
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Scott Blake Harris, Esq. (By Mail) (By US Mail)
Henry Goldberg, Esquire, Counsel for Proxim, Inc. (By Courier)

Wireless Ethernet Compatibility Alliance

Ex Parte Comments in ET Docket No. 99-231

April 10, 2000

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1.0 Introduction

Several aspects of the proposed rule changes to authorize Wide Band Frequency Hopping (WBFH) systems remain in contention. In an attempt to reach resolution, Kodak proposed[1] that the Commission accept the technical requirements of ETS 300 328 as alternative criteria for granting certification for devices which operate in the 2.4 GHz ISM band.

WECA regards this proposal as a positive development. However, adoption of ETS 300 328 would result in a significant increase in the spurious emission limits in restricted bands (2310 – 2390 MHz and 2483.5 - 2500.0 MHz). This measure will significantly broaden the scope of this proceeding, and will undoubtedly draw pointed comments from the Mobile Satellite Services (MSS) interests. Rather, without changing the current limits for spurious emissions, ETS 300 328 can serve as a useful basis for discussion of WBFH rules.

Regarding operating rules for FHSS radios, ETS 300 328 stipulates the use of 20 well defined, non-overlapping channels. It further imposes a limit on Effective Isotropic Radiated Power (EIRP) of 100 mW, and a minimum hop rate of 2.5 hops/sec.

As a further step toward promoting efficient use of the spectrum, and in hopes of arriving at a resolution acceptable to all parties involved, WECA offers three modifications to the requirements of ETS 300 328. The resulting proposal is summarized in Table 1.0-1.

[1] Ex parte Comments of Eastman Kodak Co., Submission in ET Docket 99-231, February 15, 2000

Parameter	Comments
Maximum Channel Width	4 MHz (non-overlapping channels)
Tx Power Limit	60 mW
Minimum Hop Rate	2.5 hops/sec
Maximum Hop Rate	100 hops/sec (for systems having >1 MHz channel width)
Minimum # Channels	20 (non-overlapping)
Receiver Performance Test	interference rejection test (receiver desensitization, see Table 4.1-1)
ETSI Compatible?	Yes

Table 1.0-1 Key Points of WECA Proposal

ETS 300 328 explicitly precludes the use of overlapping channels and therefore requires a corresponding reduction in the number of FHSS channels in proportion to the expansion in channel width. It also imposes transmit EIRP limitations. ETS 300 328 does not require the use of a higher hop rate.

However, the EIRP limit in ETS 300 328 is inconsistent with the Commission's previous rulings in regard to FHSS systems. In the past, the Commission has ruled that power for FHSS systems should be reduced in proportion to the ***square*** of the reduction in the minimum number of hopping channels. See 47 C.F.R. Sec. 15.247(b)(2). Comments submitted by the IEEE LAN/MAN Standards Committee[2] and by Silicon Wave[3] indicate that power reductions of this magnitude are still not completely adequate to protect existing systems from increased interference. However, in the interest of developing simple rules that will provide some meaningful level of protection for existing systems, WECA proposes adoption of power limits for WBFH systems that are proportional to the square in the reduction in the minimum number of hopping channels. For WBFH systems, the minimum number of channels is 20. This results in a power limit of 60 mW.

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[2] Annex 1 of the IEEE 802 LAN/MAN Standards Committee, Second ex parte letter in ET Docket 99-231, *"Interference Potential of Wide Band Frequency Hopping Systems on Packet Data Systems"*.

[3] Reply Comments of Silicon Wave, submission in ET Docket 99-231, December 1999.

WECA further proposes an interference rejection test for WBFH receivers. The proposed receiver test would apply only to WBFH systems having channel widths in excess of 1 MHz. The basis for this test is already in Section 15.247 (a)(1), which states:

"The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals."

Receiver tests have long been part of the equipment authorization process for DSSS equipment, and have not been an undue burden for manufacturers. WECA urges the Commission to adopt a test for WBFH receivers which confirms compliance with a requirement already in the rules. Such a test is necessary to ensure to ensure that receiver performance is adequate to minimize retransmitted packets, and hence to prevent unnecessary interference.

Finally, WECA proposes a maximum limit on hop rate of 100 hops/sec for WBFH systems that use a channel width of greater than 1 MHz. This limit would not apply to FHSS systems that have a channel width of $\leq$ 1 MHz. Simulations submitted in this proceeding[4] [5] have shown that higher hop rates generally increase interference to other systems, which use packet-based transmissions. A hop rate limitation of 100 hops/sec is above the 50 hops/sec rate described by CUBE in its filing in this proceeding. Therefore, this limit should have no effect on the system currently being developed by HomeRF.

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[4] *"Interference Potential of WBFH Systems on Packet Data Systems"*, D.C. Johnson, Submission of IEEE 802 (Annex 1), ET Docket 99-231, October 1999.

[5] *"Analysis of WBFH Power Reductions and Increased Hop Rate on Other Users of the 2.45 GHz ISM Band"*, Submission of Intersil Corp., ET Docket 99-231, September 1999.

2.0 Background

Contrary to the claims of proponents, the current WBFH proposal would not "improve worldwide harmonization of FHSS rules."[6] The proposed WBFH parameters are non-compliant with ETSI regulations for three reasons:

1. Proposed WBFH rules include the use of overlapped channels. This conflicts with ETSI rules, which explicitly prohibit overlapped channels.
2. The maximum Home RF channel width of 5 MHz would not comply with ETSI requirements for 20 non-overlapping channels in the 2400 – 2483.5 MHz ISM band.
3. The proposed transmit power limits for the 3 MHz and 5 MHz channels (330 mW and 200 mW, respectively) exceed the ETSI limit of 100 mW EIRP.

The recent submission by Kodak[7] to the Commission in ET Docket 99-231 proposes to adopt the technical requirements of ETS 300 328 as an alternative to the Commission's current requirements for radios operating in the 2.4 GHz ISM band. This would prohibit the use of overlapped channels. Intersil[8] and others [9, 10, 11, 12, 13] (including some proponents of WBFH [14, 15]) have commented extensively on the drawbacks associated with the use of overlapping channels. Further, while ETSI requirements place an effective limit on FHSS channel width of 4 MHz

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[6] Reply Comments of CUBE, submission in ET Docket 99-231, November 19, 1999, page 44.

[7] Ex Parte filing by Kodak, submission in ET Docket 99-231, February 15, 1999.

[8] Zyren and Gandolfo, "Analysis and Simulation of Overlapping Frequency Hopping Channels", submission in ET Docket 99-231, September 1999.

[9] Reply Comments of Ericsson, submission in ET Docket 99-231, November 1999.

[10] Reply Comments of Lucent Technologies, Inc., submission in ET Docket 99-231, November 1999.

[11] Reply Comments of the Wireless Ethernet Compatibility Alliance, submission in ET Docket 99-231, January 2000.

[12] Comments of IEEE 802.11 Working Group, submission in ET Docket 99-231, July 1999.

[13] Comments of Aironet, Inc, submission in ET Docket 99-231, October 1999.

[14] Comments of BreezeCOM, submission in ET Docket 99-231, October 1999.

[15] Comments of Texas Instruments, submission in ET Docket 99-231, October 1999.

(versus the WBFH request for a maximum channel width of 5 MHz), the system being built by HomeRF in fact complies with the ETSI 4 MHz channel bandwidth limit.[16]

The Kodak proposal addresses some of the major issues, but leaves important considerations to be dealt with. ETSI includes a limit on EIRP, while the Commission's rules have a limit on transmit power. The Commission's previous rulings have held that for FHSS systems, transmit power should be reduced in proportion to the square of the reduction of the minimum number of hopping channels.[17] As described more fully below, the same principle should apply here.

In addition, the Commission's rules require FHSS receivers to have input bandwidths that match the transmit bandwidth of their respective transmitters. But the Commission has not established quantitative criteria nor required testing for compliance with this requirement for conventional FHSS operation. If FHSS channel widths expand beyond 1 MHz, however, this requirement will become increasingly critical. WECA therefore proposes specific criteria as set forth in Section 4 below for WBFH systems to show compliance with this measure.

Finally, extensive analysis has indicated that increasing the hop rate is not an effective interference mitigation measure. On the contrary, increasing hop rate can actually increase interference to other packet based radio systems. WECA therefor proposes a limitation on hop rate of 100 Hz for FHSS systems having channel widths in excess of 1 MHz. This limit is higher than the hop rate of the WBFH radios now being developed by HomeRF, and thus should not affect those systems.

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[16] Reply Comments of CUBE, submission in ET Docket 99-231, November 19, 1999, page 45.

[17] Report and Order, 12 FCC Record 7488 (1997).

3.0 WBFH Transmit Power Limits

ETS 300 328 has an EIRP limit of 100 mW. However, Section 15.247 of the Commission's rules places a limit on transmit power rather than EIRP. The Commission has previously ruled that transmit power for FHSS operation in the 915 MHz band must be reduced in proportion to the square of the reduction in the minimum number of hopping channels. Further, the IEEE LAN/MAN Standards Committee showed that a power reduction in excess of this magnitude was necessary to completely neutralize the interference suffered by IEEE 802.11 packet-based WLAN systems. This finding was confirmed by Silicon Wave in their analysis of the effects of WBFH on Bluetooth receivers.

Application of the ETSI rules for FHSS systems will result in a reduction in the minimum number of hopping channels by a factor of about four. Therefore, by applying a power reduction proportional to the square in the reduction in the minimum number of hopping frequencies, the transmit power limit would be reduced by a factor of 16, or to about 60 mW. This level of power reduction for a 4 MHz channel is consistent with the comments of Texas Instruments[18] and Silicon Wave[19] in this proceeding. While this level of power reduction is not sufficient to completely neutralize the interference effects of WBFH systems on legacy Part 15 equipment, WECA nevertheless proposes this limit in an effort to reach a compromise in this proceeding. Based on the foregoing, WECA urges the Commission to adopt a transmit power limit of 60 mW for WBFH transmitters.

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[18] Comments of Texas Instruments, submission in ET Docket 99-231, October 1999.

[19] Reply Comments of Silicon Wave, submission in ET Docket 99-231, December 1999.

4.0 WBFH Receiver Test

Section 15.247(1)(1) of the Commission's Rules provides:

"The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters..."

Moreover, the Commission has previously emphasized the importance of FHSS receiver performance:

"We agree that it is necessary to treat frequency hopping transmitters and receivers as a system in order to ensure that the spectrum efficiencies made possible through true spread spectrum operations are in fact achieved. We therefore are specifying certain basic requirements for frequency hopping receivers."[20]

In a recent Public Notice, the Commission released guidelines for measurement of FHSS systems. In regard to the receiver input bandwidth requirement described above, manufacturers must:

"Describe how the associated receiver(s) complies with the requirement that its input bandwidth (either RF or IF) matches the bandwidth of the transmitted signal"[21].

The Commission has not established any quantitative criteria for compliance with the receiver bandwidth requirement. WECA urges the Commission to adopt a WBFH receiver interference rejection test (sometimes referred to as receiver desensitization) as a means of verifying compliance with this existing requirement. This test is a measure of how well an FHSS receiver can discriminate between a desired signal and an interfering FHSS signal offset from the

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[20] Report and Order, FCC Record 4123 (1990), paragraph 26.

[21] *"Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems"*, FCC Public Notice, DA 00-705, March 30, 2000.

desired signal by some specified number of channels. All of the major FHSS standards include such a test, including IEEE 802.11FH, Bluetooth, and HomeRF.

The CUBE Reply Comments show results for this type of testing.[22] A portion of that data is reproduced below in Table 4.0-1. When performing interference rejection testing, the receiver sensitivity (minimum required signal strength) is determined for a given bit error rate (BER). The frequency of the desired signal is held constant throughout the procedure.

Offset Frequency from Center (MHz)	**SIR (dB) IEEE 802.11 FH Interference**
-3	< -30
-2	-18
-1	15
0	14
+1	15
+2	-11
+3	-28

Table 4.0-1 CUBE Receiver Interference Rejection Test Data from CUBE Filing of 11/19/99

Once receiver sensitivity is determined, the desired signal is increased (usually 3 dB). An interfering signal is then placed on a channel offset from the desired signal by some predetermined number of channels. The interfering signal for the data of Table 4.0-1 above is an IEEE 802.11 FH transmitter, while the desired signal was generated by a Proxim OpenAir transmitter. (This is a bit unusual, as the interfering signal more typically uses the same modulation format as the desired signal, but has an uncorrelated data sequence.) The interfering signal strength is increased until the BER for the receiver on the desired channel exceeds the sensitivity threshold.

The data of Table 4.0-1 indicates that the FHSS receiver under test has a bandwidth of susceptibility to interference that is three times the hopping channel bandwidth of its corresponding transmitter. Indeed, FHSS systems marketed today vary greatly in terms of their interference rejection characteristics.

[22] Reply Comments of CUBE, submission in ET Docket 99-231, Table 1, page 35, November 1999.

Authorization of WBFH devices will result in a radical expansion in the FHSS channel width. In the case of WBFH systems having 4 MHz channels, the total bandwidth of susceptibility could easily exceed 12 MHz in the absence of a receiver compliance test. Unless adequate filtering is used, these systems will be more susceptible to interference and background noise, including interference from other WBFH transmitters, over several channel widths. Interference from other WBFH transmitters will require frequent retransmission of packets. Such retransmission increases interference to other users. In addition, not only will systems using adequate filtering be less susceptible to interference, but overall receiver sensitivity will be enhanced by effectively reducing the receiver noise bandwidth. The enhanced receiver sensitivity will reduce requirements on transmitted RF power. This will improve the coexistence prospects for all systems utilizing the 2.4 GHz band. Interference rejection testing will encourage manufacturers to use improved filtering and thus will promote effective use of the spectrum.

4.1 WBFH Interference Rejection Requirements

Based on the above discussion, WECA urges the Commission to adopt an interference rejection test as a part of the WBFH equipment authorization procedure. Receiver performance tests have long been required for manufacturers of DSSS equipment, and have not posed an undue burden. (In fact, alternative requirements for the DSSS receiver performance test are being evaluated within this proceeding.) Interference rejection requirements are already part of the IEEE 802.11 FH, HomeRF, and Bluetooth specifications.

WBFH receiver interference rejection testing should be performed at room temperature as described below:

1. WBFH receiver sensitivity will be measured for a predetermined BER while operating on a fixed frequency. The receiver sensitivity and corresponding BER shall be recorded.
2. The desired signal shall be increased by 3 dB.
3. A continuously transmitted interfering signal (using the same modulation format as the desired signal, but having an uncorrelated data sequence) located at a specified offset frequency shall be linearly combined with the desired signal.

4. The strength of the interfering signal shall be increased until the BER for the WBFH receiver under test exceeds the threshold for sensitivity as recorded in Step 1.
5. The receiver shall comply with the minimum interference rejection requirements of Table 4.1-1 on at least 75% of the hopping channels (interference rejection need not be measured for those frequency offsets that fall outside the 2400 – 2483.5 MHz ISM band).

Proposed minimum required interference rejection requirements as a function of offset the center frequency of the interfering signal to the center of the desired signal are shown in Table 4.1-1.

Frequency Offset (center-to-center, MHz)	**SIR (dB)**
4	≤ 0
8	≤ -20
≥ 12	≤ -30

Table 4.1-1 Minimum WBFH Receiver Interference Rejection Requirements

4.2 Discussion

Adoption of a WBFH receiver test as described herein would encourage manufacturers to use more robust channel filtering by making wider channel widths available to those radios having good interference rejection characteristics. In addition, the WBFH performance test would facilitate deployment of networks having both narrowband and wideband devices. Conventional FHSS devices having 1 MHz channel widths could be granted equipment authorization under the WBFH rules and be used in networks having only 20 channels in order to accommodate a combination of both narrowband and wideband devices within the same network.

5.0 Hopping Rate

The interference impact of frequency hopping systems on packet data systems increases with the hopping rate. This was shown by the opponents of the WBFH proposal[23] and confirmed by the supporters[24]. An upper limit on the frequency-hopping rate of WBFH systems is thus warranted. On the other hand, fast frequency hopping is necessary and desirable in some conventional frequency hopping systems, where it does not cause undue interference. Thus, no hopping rate restrictions should be placed on frequency hopping systems complying with the current 1 MHz bandwidth rule.

WECA urges the Commission to set an upper limit of 100 hop/second on the hopping rate (10 millisecond minimum dwell time) of frequency hopping systems with bandwidths exceeding 1 MHz in order to limit this interference impact on legacy packet data systems. This 100 hops per second rate would limit the impact of the hopping rate of WBFH systems with channel widths in excess of 1 MHz to approximately 5% for legacy systems operating at 11 Mb/s and to under 30% for legacy systems operating at 2 Mb/s[25].

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[23] "*Interference Potential of WBFH Systems on Packet Data Systems*", D.C. Johnson, Submission of IEEE 802 (Annex 1), ET Docket 99-231, October 1999.

[24] Reply Comments of CUBE, submission in ET Docket 99-231, Table 1, page 31, November 1999.

[25] The LMSC annex cited above shows that the hopping rate impacts the interference probability by a factor equal to the sum of the hopper dwell time and the victim packet time divided by the victim packet time. The proportions cited to legacy systems with packet lengths of 690 octets. These are typical packet lengths in LMSC standard systems.

6.0 Summary

The recent proposal put forth by Kodak suggesting the use of ETSI regulations as an alternative means of granting certification for radios operating in the 2.4 GHz ISM band is a significant step toward resolving the debate over adoption of WBFH. ETSI rules preclude the use of overlapping channels, which has been one of the chief objections to the proposed rule changes raised by WECA and several other parties. In addition, ETSI rules allow for a 4 MHz channel width, which is wide enough to accommodate the WBFH system now under development by HomeRF.

The Commission's rules as currently written have explicit limits on output power, and separate language regarding the use of directional antennas. The Commission should maintain consistency with previous rulings that have reduced FHSS system transmit power limits in proportion to the square of the reduction in the minimum number of hopping channels. WECA therefore urges the Commission to adopt a power limit of 60 mW for WBFH devices.

WECA further urges the Commission to adopt a receiver performance test for WBFH systems, as described in Section 2 above. Adoption of this test would simply introduce an affirmative means of verifying compliance with requirements that are already part of the Commission's rules. A receiver performance test is entirely consistent with the Commission's comments in previous proceedings as described above. Receiver performance tests have long been required of manufacturers of DSSS equipment, and have not posed an undue burden.

Finally, for WBFH systems having channel widths in excess of 1 MHz, a hop rate cap of 100 hops/sec will protect legacy systems from excessive interference. Engineering studies submitted to the Commission in this proceeding have indicated that higher hop rates will increase interference to other users of the 2.45 GHz ISM band. WECA therefore urges the Commission to adopt a cap of 100 hops/sec for WBFH devices having channel widths in excess of 1 MHz.

For the Commission's convenience, salient WBFH parameters as proposed by HomeRF, as well as the Kodak and WECA modifications are shown in Table 6.0-1.

Parameter	HomeRF		Kodak (2/15/00)	WECA
Channel Width	3 MHz	5 MHz	4 MHz	4 MHz
Tx Power Limit	330 mW	200 mW	100 mW (EIRP)	60 mW Tx Power
Minimum Hop Rate (hops/sec)	20	50	2.5	2.5
Maximum Hop Rate (hops/sec)	---	---	---	100 (ch. width > 1 MHz)
Min. # Hop Channels	75	75	20	20
ETSI Compatible	No	No	Yes	Yes
Rx Performance Test	No	No	No	Yes

Table 6.0-1 Comparison of HomeRF, Kodak, and WECA Proposals

7.0 Conclusions

Although ETS 300 328 cannot be adopted in its entirety, its salient FHSS parameters form the basis for a workable compromise on the WBFH issue. In order to arrive at a compromise which is consistent with previous FCC rulings and which addresses the main objectives of all interested parties, WECA has proposed minor modifications to the FHSS rules described in ETS 300 328. The modified rules would serve as an alternative to current FHSS rules as described in FCC 15.247. The measures proposed by WECA will:

a.) result in operating parameters for WBFH which are consistent with the Commission's previous rulings relating to power reductions for FHSS systems in proportion to the square of the reduction in the number of hopping channels

b.) ensure that WBFH operating rules are consistent with ETSI regulations (with the exception of the Commission's rules regarding the use of directional antennas)

c.) incorporate a WBFH receiver test which ensures compliance with requirements for FHSS systems that are already part of the Commission's Rules.

d.) Provide meaningful limitations on the increased level of interference to which systems already authorized under the Commission's Rules would otherwise have been exposed.

The main measures of the WECA proposal are summarized in Table 7.0-1.

Minimum Number of Hopping Channels	20 (non-overlapping)
Minimum Channel Width	4 MHz (to prevent overlapping channels)
Tx Power Limit	60 mW
Minimum Hop Rate	2.5 Hz
Max Hop Rate	100 Hz (for channel bandwidth > 1 MHz)
FHSS Receiver Performance Test	Yes (see Section 4)

Table 7.0-1 Summary of WECA WBFH Proposal

WECA urges the Commission to adopt these measures.