BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
Modification of Parts 2 and 15	)	
Of the Commission's Rules for	)	ET Docket No. 03-201
Unlicensed Devices and Equipment	)	

To: The Commission

COMMENTS OF ARRAYCOMM, INC.

ArrayComm, Inc. (hereinafter "ArrayComm") is pleased to submit the following Comments in the above-entitled matter.

Introduction

The Commission's proposals in this proceeding are designed to foster and facilitate the use of unlicensed systems, particularly those in the 2.4 GHz band. Culminating in the issuance of its Spectrum Policy Task Force Report[1], the Commission has endeavored to encourage the use of such systems as a way of increasing spectrum utilization. The aspects of that Report which seemed to espouse the viability of intermingling unlicensed and licensed systems in the same spectrum generated substantial opposition from licensees as well as the equipment manufacturers who supply licensed systems. The core question was whether such mixed usage would result in unacceptable interference.

The Commission in this Docket seeks to avoid that issue; its proposal(s) would only apply to unlicensed spectrum. Since all users of such systems, governed by Part 15 of the Commission's Rules, must accept any interference that they receive[2], it is the Commission's belief that with

[1] This Report was the subject of ET Docket No. 02-135; see also Statement of Chairman Powell on page 31 of this Notice.
[2] Page 2, para 3 of NPRM.

appropriate modification of its Rules these unlicensed systems can utilize improved and innovative technologies to expand their utility without a destructive increase in interference.

To that end, the Commission is proposing a number of amendments to Parts 2 and 15 of its Rules. The latter changes would, inter alia, clarify the regulations that govern the use of advanced antenna designs in unlicensed systems. As the leading developer and provider of adaptive antenna solutions, ArrayComm believes it is uniquely qualified to comment on these aspects of the proposals.

As a general statement, ArrayComm agrees with the Commission that advanced antenna systems can provide significant performance benefits to unlicensed operations and that Part 15 should be updated to provide clear guidelines for the deployment of such systems. Presaging our comments below, ArrayComm's proposal is based on the principle that the updated Part 15 guidelines should not lead to an increase in average interference levels in the unlicensed bands.

Background

The Commission points out that its current Part 15 Rules do not cover advanced antenna technologies " . . . such as sectorized antennas and phased array adaptive antennas . . ."[3] Our comments below focus on the co-channel interference behavior of advanced antenna systems. To aid in the discussion, we suggest an alternative taxonomy of these systems. Divide advanced antenna systems into one of three categories: sectorized, switched beam and adaptive. Sectorized antennas are antennas with a single fixed pattern possessing an azimuthal half-power beamwidth of less than 180 degrees. Switched beam antennas possess a small number of fixed patterns, typically with azimuthal half-power beamwidth of less than 180 degrees, and electronics for rapidly selecting an individual pattern (or "beam") for the purposes of communicating with a particular user.

Adaptive antennas combine an antenna array with means for continuously adjusting the relative phases and amplitudes of the signals driving each antenna element in the array to create a radiation pattern for communicating with an individual user.[4]

This alternative taxonomy enables a simple and straightforward analysis of the co-channel interference behavior of advanced antennas. Sectorized antennas have a single pattern. Switched beam systems have a small number of fixed patterns. Adaptive antenna systems have an infinite number of patterns.

All of these advanced antenna systems have better co-channel interference characteristics than an omnidirectional antenna because they possess directivity. Alternatively, they possess a higher ratio of EIRP to total radiated power (hereafter, "TRP") than an omnidirectional antenna.[5] When the peak gain of the pattern is oriented towards the desired user, the ratio of power delivered to the user for communication relative to power delivered elsewhere in the surrounding geography (co-channel interference) is higher than what would occur with an omnidirectional transmitting element.[6] The EIRP:TRP ratio, equivalently the amount by which an advanced antenna system reduces spatially averaged co-channel interference relative to an omnidirectional antenna for a given EIRP, is readily calculated.

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[3] Page 4, para 7, of NPRM.

[4] The amplitudes and phases are typically selected to minimize some cost function (e.g., interference transmitted to other co-channel users in the network subject to a particular gain in the intended user's direction).

[5] The TRP of a conventional sectorized antenna is simply the power applied at the antenna terminal. For switched beam and adaptive antenna systems, the TRP is the incoherent sum of the powers applied to the radiating elements in the antenna system.

[6] In non-line-of-sight environments, the meaning of "orienting" the pattern towards a desired user can be problematic. For a switched beam system, it might mean orienting the pattern in a direction that results in maximum power delivered to the user, possibly by reflection. For an adaptive array system, it might mean performing coherent multipath processing to create an energy concentration at the user. We will continue to use line-of-sight geometric analogies here, however, since they lead to the correct conclusions regarding co-channel interference behavior in the general case.

For sectorized antennas, the EIRP:TRP ratio is exactly the antenna gain. For switched beam antennas, the EIRP:TRP ratio is the gain of the least directive beam relative to an omnidirectional antenna (and generally all beams in a switched beam system have the same gain). For adaptive antenna systems in which all elements in the antenna array are identical (the nominal case), with gain G dBi, the EIRP:TRP ratio is $G+10\log_{10}M$ dB, where M is the number of elements in the array. These EIRP:TRP ratios are exactly the ratios by which the co-channel emissions produced by an advanced antenna are reduced below those of an omnidirectional antenna with the same EIRP.

ArrayComm submits that the EIRP:TRP ratio is a more appropriate metric than beamwidth for discussing the interference behavior of advanced antenna systems. The ratio directly measures the interference reduction afforded by such systems relative to an omnidirectional system. It is meaningful in highly scattering propagation scenarios where free-space pattern beamwidths are not closely related to effective radiation patterns. Finally, it is applicable to adaptive systems with complex directivity patterns that are not well described by their beamwidth.

In practice, so-called "omnidirectional" antennas may be omnidirectional azimuthally, but have gain (directivity) in the elevation plane. This may be especially true for the WISP infrastructure applications mentioned in the NPRM that are designed to support users several km away from an infrastructure access point. An elevation gain of 6 dBi is achievable with an antenna roughly two wavelengths in length (25 cm or 10" at 2.4 GHz), for example. For ease of comparison with the existing Part 15 rules, we define ET6 as the EIRP:TRP ratio of an advanced antenna system less 6 dB. An azimuthally omnidirectional antenna with 6 dBi of gain (corresponding to a 25 degree vertical beamwidth) possesses an ET6 of 0 dB. Equivalently, if the nominal elevation gain of an advanced antenna system is 6 dBi, then ET6 is azimuthal directivity component of an advanced antenna system's pattern.

Proposals

Advanced antennas could potentially be accommodated in the Part 15 rules for point-to-multipoint operations by allowing the EIRP of a system employing advanced antennas to exceed 4 W EIRP by an amount equal to the ET6 ratio of the advanced antenna system. The worst-case interference – occurring when the intended and victim receiver are in line relative to the transmitter – produced by the advanced antenna system increases in direct proportion to its ET6 ratio, but the average (per-carrier) interference remains unchanged. Note that this proposed rule is consistent with and subsumes the Part 15 point-to-multipoint emissions rule described in paragraph 5 of the NPRM.

The rule proposed above maintains average per-carrier interference at today's levels so long as only one pattern of the advanced antenna system is active at a given moment. If more than one pattern is active on a carrier at a given time, as in the case of space-division multiple access, the TRP and co-channel interference increases by a factor equal to the number of active patterns, all other considerations being equal. Hence, if maintaining the level of co-channel interference is the regulatory goal, the EIRP of a system employing advanced antennas could be allowed to exceed 4 W EIRP by an amount equal to the ET6 ratio of the advanced antenna system divided by the maximum number of simultaneously active patterns or beams per carrier. Such a rule would control the scenario presented in paragraph 11 of the NPRM regarding perversions of the rule to achieve elevated EIRP over a wide sector, as well as the scenario presented in paragraph 13 regarding overlapping beams.

Other Considerations/Summary

For the purposes of evaluating co-channel coexistence behavior, advanced antenna systems can be classified according to the number of patterns they can generate: single, multiple but finite, infinite. In all cases, the directivity of the instantaneous pattern determines average co-channel coexistence behavior: the ratio of energy delivered to the intended user to that delivered to unintended or victim users. Rules are proposed in these Comments that account for the directivity or focusing benefits of adaptive antennas without increasing average interference levels in the system.

Several additional comments are in order. First, the proposals in these Comments implicitly assume that current regulations regarding the average, network-wide levels of co-channel interference present in unlicensed operations are appropriate. Given the increasing use of unlicensed equipment and the anecdotal evidence for increasing interference among unlicensed devices including 802.11 equipment, cordless phones, Bluetooth devices, etc., we believe that any regulatory changes that might dramatically increase the average level of interference in such networks are ill-advised at this time.

Second, the proposals in these Comments and the suggestions in the NPRM will serve to increase worst-case interference. Since unlicensed operations and equipment are in some sense meant to serve the "average case," however, and since users can often avoid the worst-case scenario by moving their typically portable unlicensed equipment, we feel that the rule changes proposed herein should be adopted since they would not increase the average interference level in unlicensed bands.

Finally, the discussion in the NPRM and in this document presupposes that advanced antenna systems are used for transmission purposes only; and further that they are used to focus energy towards certain directions or locations, but do not perform more advanced adaptive antenna functions such as selective nulling. Unlicensed band operations comprise a wide diversity of equipment, with varying economics and technical characteristics. As such, it is unreasonable to assume that all unlicensed devices would be equipped with advanced antenna systems; it is even more unreasonable to assume that these advanced antenna systems would all perform sophisticated transmit and receive processing. Similarly, it is unreasonable to make assumptions about the levels of achievable advanced antenna performance and to regulate, thereby, on that basis. Developing rules that broadly address and promote the gradual introduction of advanced antenna systems into the unlicensed band is a sound course to follow. The regulatory proposals in these Comments provide a mechanism for accomplishing this that fairly treats all advanced antenna technologies and prevents an increase in average interference levels.

Respectfully Submitted,

By: /s/

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