Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	EIRP Spectral Density Limits
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Re:	Call for contributions, posted 24 Sept 99. Specifically, addresses the "maximum EIRP spectral density" equipment design parameters.
Abstract	EIRP limits of various regulatory agencies are reviewed. The tightest limits, proposed for adoption in Canada, are proposed for the 802.16.2 coexistence practice. These limits are shown to be consistent the technology most vendors propose for LMDS.
Purpose	This contribution proposes text for the section of the 802.16.2 coexistence practice on EIRP limits.
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EIRP Spectral Density Limits

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Suggested Text for Coexistence Practice

EIRP Spectral Density Limits

BWA Hubs conforming to the equipment requirements of this practice shall not produce an EIRP spectral density exceeding 14 dBW/MHz.

BWA subscriber stations conforming to the equipment requirements of this practice shall not produce an EIRP spectral density exceeding 30 dBW/MHz.

These limits apply to the mean EIRP spectral density produced over any continuous burst of transmission. The spectral density shall be assessed with an integration bandwidth of not more than 1 MHz; i.e. these limits apply over any 1 MHz bandwidth.

Background

EIRP spectral density limits are set with three key factors in mind:

1. Limits should be low enough so that regulatory requirements around the world will be met. This increases the applicability of the coexistence practice in different regions.
2. Limits should not be significantly higher than most radio technology that is likely to be deployed. Otherwise, most vendors will provide systems with significantly lower levels than the limit, and such systems will tend to suffer asymmetrically from the few systems which do use higher power.
3. Limits should be high enough to allow room for technological improvements.

Each factor is addressed in the sections below.

Survey of Regulatory Requirements

Canada

Provisional SRSP 325.35, draft 8, July 1999, which was written by the Radio Advisory Board of Canada and recommended for adoption by Industry Canada as a regulation, covers BWA systems in the band 25.35 - 28.35 GHz. The document sets limits of +30 and +14 dBW/MHz EIRP for subscriber stations and hubs, respectively.

US

FCC part 101.113 (October 1998) limits EIRP (not spectral density) to +55 dBW in most bands for BWA, with limits of +30 dBW in some bands. If we consider that the bandwidth of a BWA uplink might be as narrow as 1 MHz, then this represents a much higher EIRP spectral density than the Canadian draft regulations.

Europe

Draft EN 301 213-1 (June 1998) covers BWA systems in the range 24.25 - 29.5 GHz and limits nominal transmitter output power to +33 dBm, or +3 dBW. EIRP limits are set on a country-by-country basis in national regulations. If we consider that typical antenna gain for a BWA subscriber antenna is at least 36 dBi, and typical antenna gain for a BWA hub is at least 15 dBi, then this leads to EIRP limits of over 39 dBW for subscribers and 18 dBW for hubs. Assuming that the narrowest bandwidth practical is about 1 MHz, this leads to EIRP spectral density limits of over 39 dBW/MHz for subscribers and 18 dBW/MHz for hubs. This falls between the Canadian and US regulations.

ITU

Recommendation F.1249 (1997) is concerned with interference between BWA systems in the band 25.25 - 27.5 GHz and geosynchronous orbit satellite receivers. The recommendation limits transmitter power to +10 dBW, EIRP to +55 dBW and EIRP spectral density in the direction of certain geosynchronous orbits to +24 dBW/MHz (33 dBW/MHz when precipitation is present). We note that adherence to the Canadian regulation of +14 dBW/MHz for a BWA hub would satisfy this requirement, and use of adaptive transmit power control with a BWA subscriber station adhering to the Canadian limit of +30 dBW/MHz, produced only when precipitation is present, would meet this ITU recommendation under all conditions.

In conclusion, the Canadian proposed limits of +14 and +30 dBW/MHz for hubs and subs respectively are the most stringent limits.

State of Radio Technology

Hubs

BWA hub stations are sectorized. 90 degree sectors are common, but sectors as narrow as 15 degrees have been proposed. Vertical beamwidths tend to be 2 - 9 degrees. Thus, the highest hub antenna gain that can be envisaged is for a 15 x 2 degree sector. This is about 29 dBi.

Solid state power amplifier technology is applicable up to output compression points (at the antenna flange, after filter and coupler losses) of about 1 W. Above this level, travelling wave tubes tend to be employed. The higher cost only proves in if such a high power amplifier is used to transmit a very broad band signal, or an aggregate of narrower-band signals. Thus, an estimate of maximum spectral density can be made on the basis of a 1 W solid state power amplifier transmitting a single downstream channel. We can assume that linearity demands a back-off from the compression point of at least 3 dB. Thus, a maximum output power of -3 dBW results.

Downstream signals tend to be broader in bandwidth than upstream signals. A minimum downstream bandwidth of 7 MHz (for European spectral allocations) can be assumed.

Combining the above factors, leads to a worst-case EIRP spectral density for hubs of 17.5 dBW/MHz. Note, however, that it is highly unlikely that maximum antenna gain would be employed simultaneously with maximum output power and minimum bandwidth. If only one of these parameters is relaxed by about 3 dB (0.5 W power, or 26 dBi antenna gain, or 14 MHz bandwidth), then the technological EIRP spectral density upper limit aligns closely with the Canadian regulatory limit.

Subs

BWA hub stations typically employ parabolic antennas with beamwidths of 1 - 3 degrees. Narrower beamwidth is impractical, as it imposes requirements on wind-induced twist and sway of the tower or building to maintain pointing accuracy which cannot be reliably met. Thus, we can assume a maximum antenna gain of 42 dBi.

Subscriber stations are more cost-sensitive than hubs, and the cost of the subscriber station is strongly influenced by the output power capability. It is reasonable to assume that most subscriber stations employ lower power amplifiers than hubs. An output compression point at the antenna flange of 0.25 W is a reasonable limit. With 3 dB back-off, this leads to -9 dBW maximum output power.

Upstream signals are generally of at least 1 MHz bandwidth. It is difficult to use lower bandwidth at millimeter-wave frequencies, as the required guardbands for frequency stability become significant overheads.

Thus, an EIRP spectral density limit of +33 dBW/MHz results. As with hubs, it is unlikely that maximum antenna gain, maximum output power and minimum bandwidth would be employed simultaneously. If any one parameter is relaxed by 3 dB, then this lines up with the Canadian limit.

Technological Trends

As BWA market penetration rises, systems will be under increasing capacity pressure. Thus, cell sizes are unlikely to expand; rather, smaller cells will tend to be used. Therefore, it is unlikely that there will be a trend toward higher output power or narrower bandwidth. More likely, vendors will seek to minimize cost. This means providing the same power at lower cost through improved technology with higher yield. Thus, a need to increase EIRP power spectral density limits to keep up with improved technology is not forseen.

Conclusion

It is recommended that the 802.16.2 coexistence practice adopt the Canadian limits of +30 and +14 dBW/MHz EIRP spectral density limits.