Aggregate Antenna Gain Review for MIMO Systems

Presenter: Len Knight

TCB Workshop

April 2021

Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

Intro

- The FCC has given several workshop presentations on the subject of aggregate antenna gain in MIMO systems.
  - May 2005, April 2010, October 2012, April 2016
  - The presentation material had evolved with our understanding of the different technologies and potential interference to incumbents and stakeholders.

- The FCC has also published KDB 662911 on this subject.
  - KDB 662911 D01 Multiple Transmitter Output
  - Just like the TCB Workshop material, this KDB too has had updates and revisions to better serve the needs of manufacturers and users of MIMO technologies.

Antenna Gain and MIMO

- In its most basic definition
  Directional Gain = $G_{ant} + Array\ Gain$
  - G_{ant}: Gain of Individual Antennas (Same for Each Antenna)
  - For completely uncorrelated signals
    - Array Gain = 0 dB
  - For correlated signals
    - Array Gain = 10log(N_{ant}) dB
  - N_{ant}: Number of Transmit Antennas
- When the amount of correlation between signals is not well known, the most conservative value (that being 100% correlated signals) is
  - Directional Gain = G_{ant} + 10log(N_{ant}) dB
- The filing should include a clear and proper justification for the final directional gain used.

Relevance of Directional Gain

- Antenna gain can be a limiting factor in total output power. Case in point, limit requirements falling under §15.247 and §15.407.
  - §15.247 *de facto* antenna gain of 6 dBi
    - Conducted power reduction for directional gain exceeding 6 dBi
  - §15.407 limits base on EIRP
    - EIRP = conducted power + directional gain
- In these cases, using a most conservative method of calculating directional gain could affect a device's performance since conducted power reduction might be necessary to meet the limits of each respective rule part.
- **PLEASE NOTE:** The purpose of this presentation is not to serve as a compendium for all possible combinations of antenna types and MIMO platforms. This is a basic review. For further guidance, please reference KDB 662911.

Cyclic Delay Diversity (CDD)

- In 2012, KDB 662911 was updated to address Cyclic Delay Diversity.
  - CDD specific to 802.11 technology
  - Array Gain = 10 log(*Nant* / *Nss*)
    - *Nant = Number of transmit antennas*
    - *Nss = Number of spatial streams*
  - This improved the accuracy of directional gain calculations
  - Thus, minimizing required power reduction

- In the case of Cyclic Delay Diversity, this specific technology was evaluated, and exacting guidance given in the form of a KDB publication.

FCC Rules and Technologies and Submitting a KDB Inquiry

- Generally speaking, FCC rules are written as to be agnostic towards specific technologies. For example:
- Bluetooth
  - Operating at 2402 – 2480 MHz, Bluetooth can fit into FCC rule part §15.247 for certification.
  - This rule part generically addresses the use of that spectrum as Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.
  - Little technical distinction is mentioned in the actual rule apart from differentiating between DTS and DSS.
- LTE Bands
  - LTE Bands 2 and 25 can operate under Part 24
  - §24.229 specifies frequency block allocation, but there is no mention specific to LTE or any other dedicated platform.

Key Takeaways

- The filing should include a clear and proper justification for the actual directional gain used.
- Any FCC guidance (whether in KDB Publication or TCB Workshop presentations) should be clearly referenced.
- If the radio is capable of operating in a legacy mode, this too should be addressed in the test report and filing.
  - Some legacy modes may require a more conservative estimate
  - If no legacy mode, then specify that as well

Thank You!