Revisions to MIMO KDB Publication # 662911 D01

"Emissions Testing of Transmitters with Multiple Outputs in the Same Band"

TCB Workshop

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Steve Martin

Overview of KDB 662911

KDB Publication 662911 consists of three documents.

They apply to unlicensed and licensed devices.

- **# 662911 D01 Conducted output emission measurements (Revised)**
  - How to sum emission measurements across output ports
  - How to compute directional gain (including array gain)
- **Appendix I to 662911 D01** (separate file in draft KDB section): **New Draft Technical Report** *FCC/OET 13TR1003, "Directional Gain of IEEE 802.11 MIMO Devices Employing Cyclic Delay Diversity".*
  - Provides technical basis for array gain formulas for IEEE802.11 CDD
- **# 662911 D02 Conducted and radiated emission measurements for devices driving cross-polarized antennas**

KDB Changes: Summing Spectrum Measurements

- Alternatives for measuring
  - In-band power spectral density and
  - Out-of-band and spurious emissions.
  - Measure and sum spectra across outputs
  - NEW → *Measure and sum spectral maxima across outputs*
  - Measure and add 10 log(N_{ANT}) dB

KDB Changes: New Gain Formulas

New formulas for directional gain with spatial multiplexing where antenna gains are not equal

- Option 1: Substitute maximum antenna gain into formulas for equal antenna gains
- Option 2: Applies if each transmit antenna can be driven by only one spatial stream

$$DirectionalGain = 10 \cdot \log \left[\frac{\sum_{j=1}^{N_{SS}} \left\{ \sum_{k=1}^{N_{ANT}} g_{j,k} \right\}^2}{N_{ANT}} \right]$$

where

N_{SS} = # spatial streams of data;

N_{ANT} = total # of antennas

$g_{j,k} = 10^{G_k / 20}$ if the kth antenna is being fed by spatial stream j, or zero if it is not;

G_k is the gain in dBi of the kth antenna.

Equivalent to $10 \log[(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN/20})^2 / N_{ANT}]$ if one spatial stream

- Option 3: Applies if a transmit antenna can be driven by more than one spatial stream

$$DirectionalGain = 10 \cdot \log \left[\frac{\sum_{j=1}^{N_{SS}} \left\{ \sum_{k=1}^{N_{ANT}} g_{j,k} \sqrt{P_{j,k}} \right\}^2}{N_{ANT}} \right]$$

where

$P_{j,k}$ is the relative normalized power (in linear terms, not decibels) of spatial stream j feeding the kth antenna, normalized such that

$$\sum_{j=1}^{N_{SS}} \left\{ \sum_{k=1}^{N_{ANT}} P_{j,k} \right\} = N_{ANT}$$

Note: $P_{j,k} = 0$ if spatial stream j does not feed the kth antenna.

KDB Changes: Directional Gain for Out-of-Band and Spurious Measurements

Revised section: "Directional Gain Calculations for Conducted Out-of-Band and Spurious Measurements"

- Refer to methods used for in-band gain (except for narrowband lines)
  - Incorporates special cases such as unequal antenna gains, spatial multiplexing, cyclic delay diversity, etc.
- Clarification: Directional gain calculations for out-of-band and spurious emissions are <u>not</u> required for:
  - *Radiated* measurements
  - Conducted measurements used to demonstrate compliance with a *relative* out-of-band limit
  - <u>*Conducted measurements, if limits are specified as absolute conducted power levels (rather than EIRP, ERP, or field strength) in a given bandwidth with no required reduction based on directional gain*</u>
    - Applicable to many licensed devices
    - Must still sum emission measurements across outputs

ADDED

KDB Changes: Formatting & Clarification

- Formatting
  - Added paragraph and heading numbers
  - Added Table of Contents
- Clarifications
  - KDB also applies to hosts with multiple modular transmitters in same band
  - Requirement to sum outputs:
    - Sum in power units; or equivalently,
    - *Sum in voltage-squared units*
  - General restructuring and clarification

KDB Changes: New Appendix I for 662911 D01

Technical Report *FCC/OET 13TR1003:*

"Directional Gain of IEEE 802.11 MIMO Devices Employing Cyclic Delay Diversity"

- Provides technical basis for formulas for array gain of IEEE 802.11 transmitting with Cyclic Delay Diversity.
- **Draft – Comments welcome through draft KDB publication system!**

Coming in the Future????

Possible changes to array gain calculations for closed loop beamforming

- Slightly lower broadband array gain
- Scope will be limited based on supporting data
  - Measurement data for indoor com's at 5 GHz

Anyone with relevant data can submit to steve.martin@fcc.gov

This presentation provides only a summary.
See the actual KDB pub for details.

Questions and Answers

Thanks!