Federal Communications Commission
Office of Engineering and Technology
Laboratory Division Public Draft Review

Draft Laboratory Division Publications Report

Title: MIMO with cross-polarized antennas in rules with EIRP limits

Short Title: EIRP for MIMO and Cross Polar Ant

Reason: New Publication

Publication: 689094

Keyword/Subject: MIMO with cross-polarized antennas in rules with EIRP limits

First Category: Radio Service Rules

Second Category:

Third Category:

Question:

For antenna-port conducted measurements on MIMO devices, FCC KDB Publication 662911 specifies that the power levels from the outputs should be added. However, in the special case of a MIMO device with two outputs driving a cross-polarized pair of linearly polarized antennas, a linearly polarized measurement antenna aligned with one of the transmit antenna polarizations will see only the emissions from that antenna. Given that a radiated emission measurement might respond to only one output at a time in that case, is it really necessary to sum the power levels from the two outputs when performing conducted measurements.

Answer:

Interpretation of output power requirements for a device with two outputs driving linearly polarized antennas that are cross-polarized with respect to each other depends on the rule part and the correlation of the transmitted signals.

For rule parts that specify limits on antenna-port conducted power (e.g., 15.247, 15.407, 90Y), the output power must be summed across the outputs. This interpretation applies even when power limits

must be reduced based on directional gain of the transmit antenna, resulting in a limit that is similar to an EIRP limit. See FCC KDB Publication #662911 for more information.

For rule parts that specify limits as EIRP or ERP (e.g., Parts 27C and 90Z), compliance may be demonstrated by radiated measurements or by combining conducted power measurements with antenna gain (including array gain, if any). Unless the rule specifies how to handle circular, elliptical, or cross-polarizations, we will interpret EIRP or ERP limits as applying to the maximum emission that would be observed with a linearly polarized measurement antenna. For conducted measurements, the EIRP or ERP of each of the two transmit chains is computed separately based on measured output power and antenna gain. The decision of whether or how to combine the results is then made as follows.

(1) If the transmitter output signals are completely uncorrelated as defined in FCC KDB Publication #662911, then each of the two EIRPs or ERPs must individually be below the limit.

(2) If one of the transmitter outputs is a 90-degree phase-shifted replica of the other and the phase centers of the two antennas are co-located (as would be the case when creating a circularly polarized transmission using linearly polarized antennas), then the each of the two EIRPs or ERPs must individually be below the limit [as in (1)].

(3) If the transmitter output signals are correlated as defined in FCC KDB Publication #662911 and the conditions of (2) do not apply, then the sum of the two EIRPs or ERPs must be below the limit.

The explanation for case (3), above, is as follows. Suppose two transmit chains individually produce field strengths Ea and Eb at a point in space on the main response axis of the antennas and that the two signals are perfectly correlated at that point. If the antennas had the same polarizations, the field strengths would directly add. However, with cross-polarization the two field strengths must be combined as vectors with one oriented at a 90 degree angle with respect to the other. The combined field strength has a magnitude equal to the square root of the sum of the squares of the two field strengths, or, equivalently, the square of the combined field strength is equal to the sum of the squares of the two individual field strengths. Since EIRP and ERP are proportional to the square of the field strength, the combined EIRP or ERP is equal to the sum of the individual EIRPs or ERPs.