Directional Gain and EIRP Calculations for Transmitters with Multiple Outputs

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April 13, 2016

Transmitters w/ Multiple Outputs (Same Band)

- Directional Gain of Multiple Antennas
- Relevance of Directional Gain to Compliance Tests
- Directional Gain Calculation
  - Correlation
  - Co-polarized Antenna Configurations
  - Cross- polarized Antenna Configurations
  - Hybrid Antenna Configurations
    - Combination of Co- polarized and Cross Polarized Antennas

Directional Gain of Multiple Antennas

- Multiple antennas transmitting correlated Signals:
- Effective Directionality Greater than Directionality of Individual Antenna
- Directional Gain a Function of
  - Relative Phase of the Transmitted Signals
  - Relative Location of the Antennas
  - Number of Antennas
  - Excitation Method of Each Antenna
- This Increased Gain Is Referred to as Array Gain in FCC KDB Publications

Relevance of Directional Gain to Compliance Tests

- When Requirements Stated in Terms of Conducted Power Assuming Certain Antenna Gain
  - 15.247, 15.407, etc.
- When Radiated Power Is Verified Through (Conducted) Power Measurement
  - Antenna Gain Needed to Calculate EIRP

Directional Gain and EIRP Calculation

Co-polarized Antenna Configuration

Directional Gain Calculations (co-pol)

In-Band Measurement, Equal Antenna Gains

- If Any Transmit Signals Are Correlated:
- Directional Gain= $G_{ant} + 10\log(N_{ant})\ dBi$
  - N_{ant}: Number of Transmit Antennas
  - G_{ant}: Gain of Individual Antennas (Same for Each Antenna)

- If All Transmit Signals Are Completely Uncorrelated:
- Directional Gain= G_{ant}

Directional Gain Calculations (co-pol)

In-Band Measurement, Unequal Antenna Gains

- If Any Transmit Signals Are Correlated:
- Directional Gain= $10\log[(10^{\frac{G_1}{20}}+10^{\frac{G_2}{20}}+...+10^{\frac{G_n}{20}})^{2}/N_{ant}]\ dBi$
- If All Transmit Signals Are Completely Uncorrelated:
- Directional Gain= $10\log[(10^{\frac{G_1}{10}}+10^{\frac{G_2}{10}}+...+10^{\frac{G_n}{10}})/N_{ant}]\ dBi$

N_{ant}: Number of Transmit Antennas

G_1, G_2,..., G_n: Gain of Individual Antennas

EIRP Calculations (co-pol)

With Directional Gain Known

- EIRP (dB)= Total Transmit Power+ Directional Gain
- Example: N_{ant} Transmit Antennas Each with the same Gain Transmitting Correlated Signals

EIRP= (Sum of Conducted Power)+ $G_{ant} + 10\log(N_{ant})$

Total Transmit Power

Directional Gain

Directional Gain and EIRP Calculation

Cross-polarized (Orthogonal) Antenna Configuration

Directional Gain Calculations (cross pol)

Cross-polarized (Orthogonal) Antennas w/ N_{ant}=2:

- Directional Gain= G_{ant}

- If Antenna Gains not the Same the Larger Gain Applies
- If N_{ant}>2 and the Antennas are piecewise Orthogonal:
  - Directional Gain Is Calculated for every two Orthogonal Antennas and the Total Gain Is Calculated Either Algebraically or Vectorially

EIRP Calculations (cross pol)

Cross-polarized (Orthogonal) Antennas w/ N_{ant}=2:

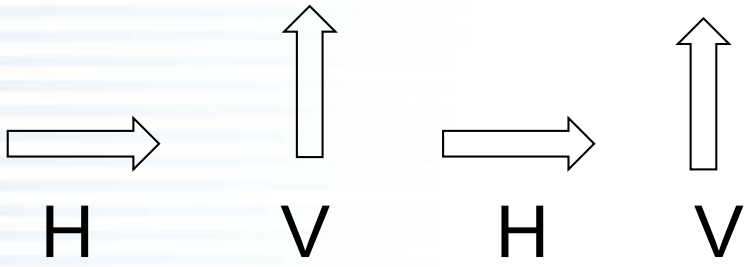
- If Signals Completely Uncorrelated, or One Output is a 90 deg Phase-shifted Replica of the Other:
  - No Need to Sum the EIRPs
  - Each EIRP Must Be Below the Limit
- If Signals Correlated and No Phase Difference:
  - The Sum of the Two EIRPs Must Be Below the Limit

Directional Gain and EIRP Calculation

Hybrid Antenna Configuration

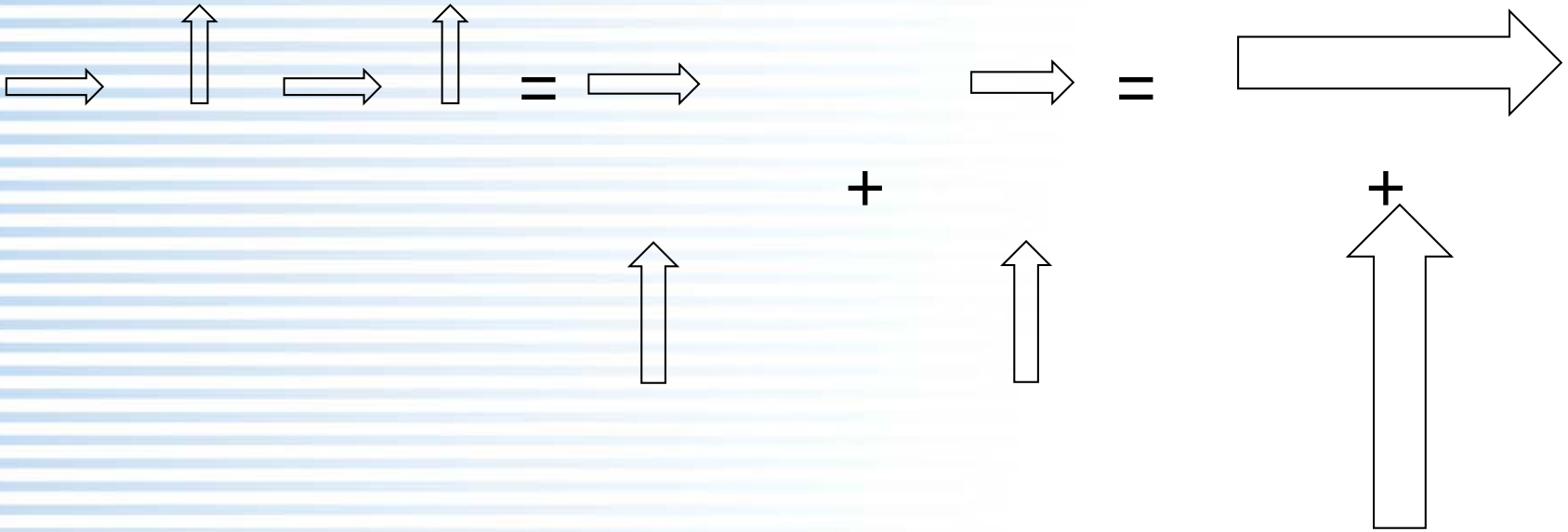
Hybrid Antenna Configuration

- A System that Utilizes a Combination of Co-polarized Radiators as well as Cross-polarized Radiators, for example:
- A Composite Transmitter with 4 Output Ports with 2 Vertically-Polarized Antennas and 2 Horizontally-polarized Antennas



Directional Gain and EIRP Calculation (Hybrid)

- Step 1: Break Down the System to Two Co-polarized Antennas
- Step 2: Compute the Gain for Co-polarized subgroup Individually
- Step 3: Apply the Cross-Polarized Guidance to Calculate the EIRP



References

- KDB Publications 662911 D01
- KDB Publications 662911 D02
- OET Report FCC/OET 13TR1003