Smart Antenna Systems

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TCB approval list

➢ TCB's can only approve these specific systems.

1) Phased array systems
2) Sectorized systems
3) Spatial Multiplexing "MIMO*" systems with or without cyclic delay diversity.

➢ Check the operational description to ensure that the device is one of the above systems. Do not rely on marketing literature alone.

➢ Only Spatial Multiplexing "MIMO" systems or Phased array "MIMO" can be approved.

➢ TCB's cannot approve systems using a combination of the above. For example, TCB's cannot approve a Phased array Spatial Multiplexing "MIMO" system.

➢ *It is noted that the term MIMO, an acronym for Multiple Input Multiple Output, has been used to describe some devices that employ phased array technology rather than spatial multiplexing technology. Such devices would fit into the phased array category used in this document.

Type of operation

➢ Because the type of operation determines the applicable requirements (e.g. output power),

devices in Section 15.247 or 15.407 must be categorized as one of the following as described in the following pages.

- Point to point system(P2P),
- Point to multipoint(P2MP) system
- Smart antenna system (SAS) under Section 15.247(c)2.

➢ Therefore, review the filing to ensure that the type of operation is correct.

SAS system

➢ Section 15.247(c)2 Smart Antenna System (SAS) operation.

- Operation at 2.4 GHz under 15.247(c)2.

- More than two beams are formed.

- Communication to multiple or mobile receivers allowed.

- Different information is sent to different receivers.

  - Does not include occasional management/control signals or occasional multicasting.

- Sectorized systems are allowed.

P2P System

➢ Point to point (P2P) system. Communication from one fixed point to another fixed point.

- Includes phased array systems communicating to one fixed receiver at a time.
  - Broadcasting is not allowed.
  - The point to point link should should be achieved only by the intended recipient receiving the signal by way of the directional angle of the antenna modified for individual transmissions.
- Does not include sectorized systems communicating to one receiver at a time except those that qualify as a SAS system.

P2MP System

➢ Point to multipoint (P2MP) system. Communication to multiple or mobile receivers.

  ▪ Includes all Sectorized systems except those that qualify as a SAS systems.

Determine Output power limit

➢ Output power limit is determined by….

- Rule part applied
  - 15.247 or 15.407
- Frequency band
- Type operation
  - Point to point (P2P) system
  - Point to multipoint (P2MP) system
  - Smart Antenna (SAS) system
    - Operates under 15.247(c)2i-iv.
- Directional gain

Directional Gain Computation

➢ Phased array systems
  ▪ Directional gain = gain of antenna element + 10 log(# of TX antenna elements)
➢ Sectorized systems
  ▪ Directional gain = gain of each antenna
➢ Spatial Multiplexing "MIMO" system
  ▪ For any spatial multiplexing "MIMO" mode in which the elements are always driven incoherently at each frequency…
    • Directional gain = gain of each antenna
  ▪ For all other modes that drive multiple antenna elements, including legacy modes for communicating with non-MIMO devices…
    • Directional gain = gain of antenna element + 10 log(# of TX antenna elements)

Output power

➢ Except for devices complying with Section 15.247(c)2i-iv, conducted output power refers to the total power within a given band.

 - The Spread Spectrum bands 902-928, 2400-2483.5 and 5725-5850 MHz and the UNII bands of 5150-5250 MHz, 5250-5350 MHz, 5470-5725 MHz, and 5725-5825 MHz are all considered separate bands—each subject to its own in-band power limit.

 - If a device can transmit simultaneously on the same or different channels within one of those bands, the power must be summed across channels within the band.

➢ Signal combiners should be avoided because it can produce anomalous results if the summed signals exhibit any correlation

Output power measurement

- ➤ P2MP systems
  - For each band, Sum power measurements across all transmitter outputs for all simultaneous transmissions on all channels.

- ➤ P2P systems
  - Sum power across all transmitter outputs.
    - Only one transmitted beam allowed at a time.

Output power measurement

➢ SAS systems operating under Section 15.247(c)2i-iv

- ▪ <u>Phased array system</u>
  - Single beam power: Measure power to antenna for each beam
  - Aggregate power: Sum power measurements across transmitter outputs for simultaneously transmitted beams.
- ▪ <u>Sectorized system</u>
  - Single beam power: Measure power to each antenna element during transmission in a single beam, then sum the power measurements across elements.
  - Aggregate power : As above, but measure during transmission in simultaneously transmitted beams.
- ▪ <u>Spatial multiplexing MIMO system</u>
  - TCB's cannot approve this system as a SAS system.

Output power

➢ Review the filing to ensure that the output power was properly measured and the output power limit was calculated properly based on the type of operation, rule part and directional gain of the antenna.

Power Spectral Density

➢ Aggregate PSD across transmitters in linear power units across each transmitter output.

➢ For transmitters operating simultaneously, the combined output must meet the requirement.

- Check compliances on simultaneous transmitter outputs on the <u>same </u>frequency channels.)

Conducted out of band emissions

- ➢ Each transmitter output must comply.
- ➢ For simultaneous transmitter outputs, the combined output must also meet the requirement.
  - ▪ Check compliance when on simultaneous outputs on <u>different</u> frequency channels

Radiated emissions

- ➢ Single and multiple beam configurations (when applicable) must be considered.
- ➢ Multiple simultaneous Channels
  - ▪ Check compliance on same and different channels when applicable.
    - • Bandedge edge and Restricted bands
- ➢ Antenna installation
  - ▪ Antenna spacing
  - ▪ Beam angle and azimuth (when applicable)
    - • Measurements should be performed in a representative sampling of beam positions. For example, for a device with a single steerable beam, it is recommended that tests be performed with a three beam positions—one at each extreme steering angle and one near the middle of the steering range. In any case, ensure that the angle forming the maximum beam is tested.

Beam Overlap for SAS systems under Section 15.247(c)2i-iv

➢ A description of compliance with the maximum beam overlap requirement may be sufficient to show compliance.

➢ Description must specify…

1) Beamwidth. Do 3 dB beamwidths overlap? If 3 dB beamwidths overlap, a measurement is required if the sum of the output power is greater than or equal to the single beam output power limit for the device.

2) Antenna installation.

Describe direction and spacing.

3) Beam angle and elevation when applicable.

Beam Overlap for SAS systems under Section 15.247(c)2i-iv

➢ Radiated Beam Overlap measurement. Applicable when 3 dB beams can overlap and non-compliance is possible(e.g. device operates within 3 dB of allowed max power on overlapped beams).

➢ Beam Overlap defined. At any point, at a distance "r" from the EUT, the sum of the power received from overlapping beams on the same or different channels must be less than or equal to the Maximum EIRP allowed for a single beam.

➢ Measure the field strength E V/m for each beam at the point of overlap at distance "r". For "n" number of beams.

$$\frac{((\text{Sum 1 to n; } E1+E2+\ldots En) \times r)^2}{30} \leq \text{EIRP max Watts}$$

➢ If EIRP max is exceeded, the power in each beam must be reduced to satisfy the equation. Else, device fails.

TCB Approval Notes

- Use Smart antenna Note code SA when applicable.
    - Note Code SA: Smart antenna system that uses beam steering or beam forming capabilities to form multiple beams.
- List the maximum single beam aggregate output power on the grant in the technical specification for each frequency band.
- Indicate whether the system is Phased array, Sectorized or Spatial Multiplexing "MIMO".