Introduction:

This letter is meant to clarify the predicted performance of the 3.7-Meter X/Ka-band transmit and receive antenna system being supplied by Comtech to Lockheed Martin against the requirements specified by the FCC. It should be noted that the X/Y antenna system is principally designed to operate with Non-Geostationary Orbit Satellite (NGSO) systems (i.e. Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites), but it can operate with GSO satellites as well. Lockheed Martin has stated its intention to utilize the antenna for tracking both NGSO and GSO systems. As such when looking at the requirements set forth from the FCC, there are no actual performance requirements stated for NGSO antenna operation. Therefore, we have tried to quantify the performance of this antenna to the requirements for Geostationary Orbit Satellite systems listed in Title 47 CFR Part 25.209. Several of the paragraphs under this provision were used due to the various frequencies being used. Bottom line, the antenna meets most of the FCC requirements in X-band and Ka-band, but there are a few instances where it does not comply by minor amounts. Our assessment is that the antenna is fit for purpose at the stated frequency ranges.

Discussion:

The specific frequency bands this antenna operates in are not covered by these regulations, however, we used these as general guidelines to assess the performance. For the X-Band portion transmitting 7.0 – 7.25 GHz, the use of paragraph 25.209 (a) (1) for the co-polarized beam and what we call the Azimuth patterns states as follows:

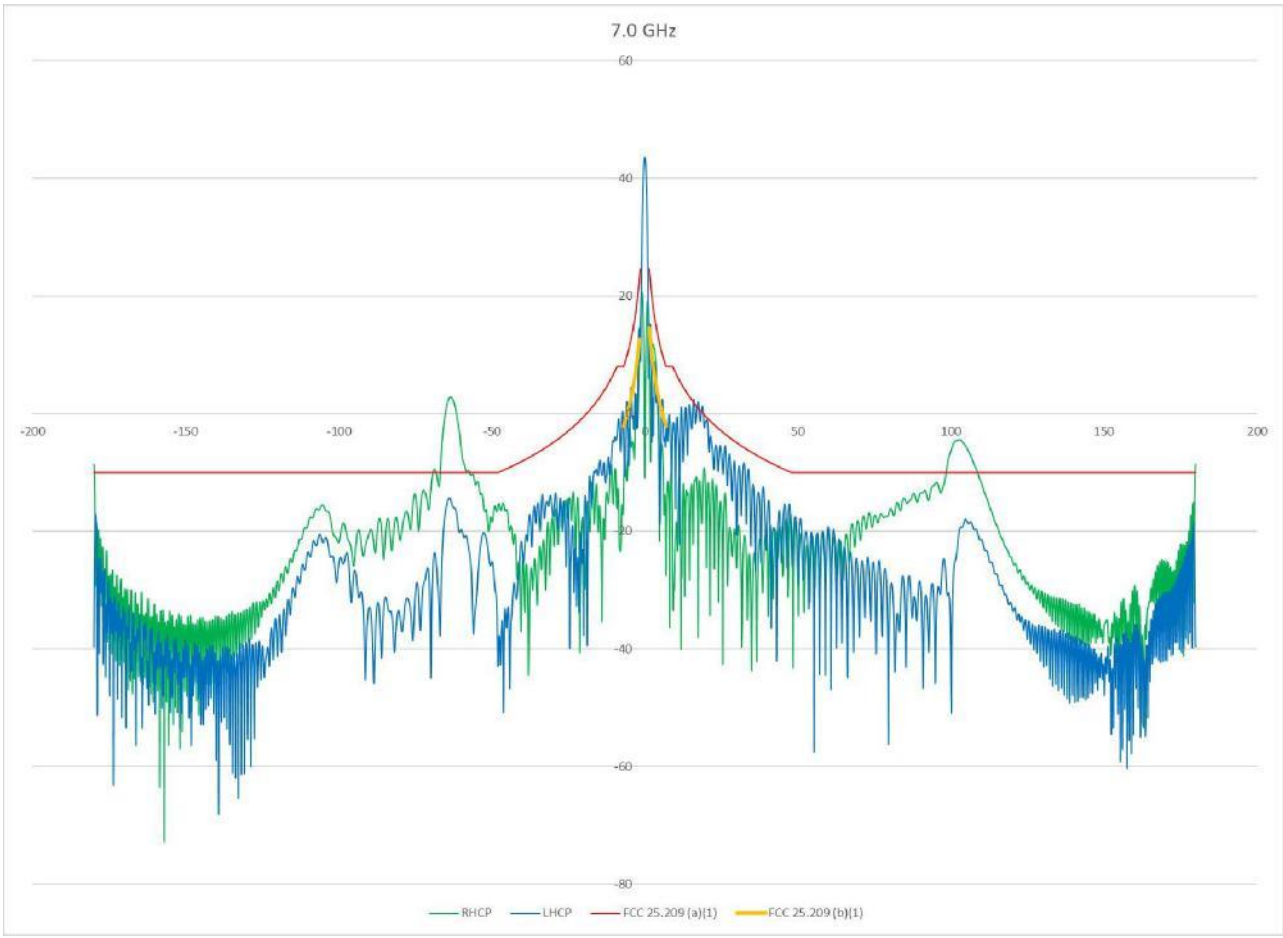
> Except as provided in paragraph (f) of this section, the co-polarization gain of any earth station antenna operating in the FSS and transmitting to a GSO satellite, including earth stations providing feeder links for satellite services other than FSS, may not exceed the following limits:
>
> In the plane tangent to the GSO arc, as defined in § 25.103, for earth stations not operating in the conventional Ku-band, the 24.75-25.25 GHz band, or the 28.35-30 GHz band:
>
> $29-25\log_{10}\theta$ dBi for $1.5° \leq \theta \leq 7°$.
> 8 dBi for $7° < \theta \leq 9.2°$.
> $32-25\log_{10}\theta$ dBi for $9.2° < \theta \leq 48°$.
> −10 dBi for $48° < \theta \leq 180°$.
>
> Where θ is the angle in degrees from a line from the earth station antenna to the assigned orbital location of the target satellite, and dBi refers to dB relative to an isotropic radiator. This envelope may be exceeded by up to 3 dB in 10% of the range of θ angles from ±7-180°, and by up to 6 dB in the region of main reflector spillover energy.

For the cross polarization we used paragraph 25.209(b)(1) which states

> Except as provided in paragraph (f) of this section, the off-axis cross-polarization gain of any antenna used for transmission from an FSS earth station to a GSO satellite, including earth stations providing feeder links for satellite services other than FSS, may not exceed the following limits:
>
> (1) In the plane tangent to the GSO arc, for earth stations not operating in the 24.75-25.25 GHz or 28.35-30 GHz bands:

$$19\text{-}25\log_{10}0 \text{ dBi for } 1.8° < 0 \leq 7°.$$

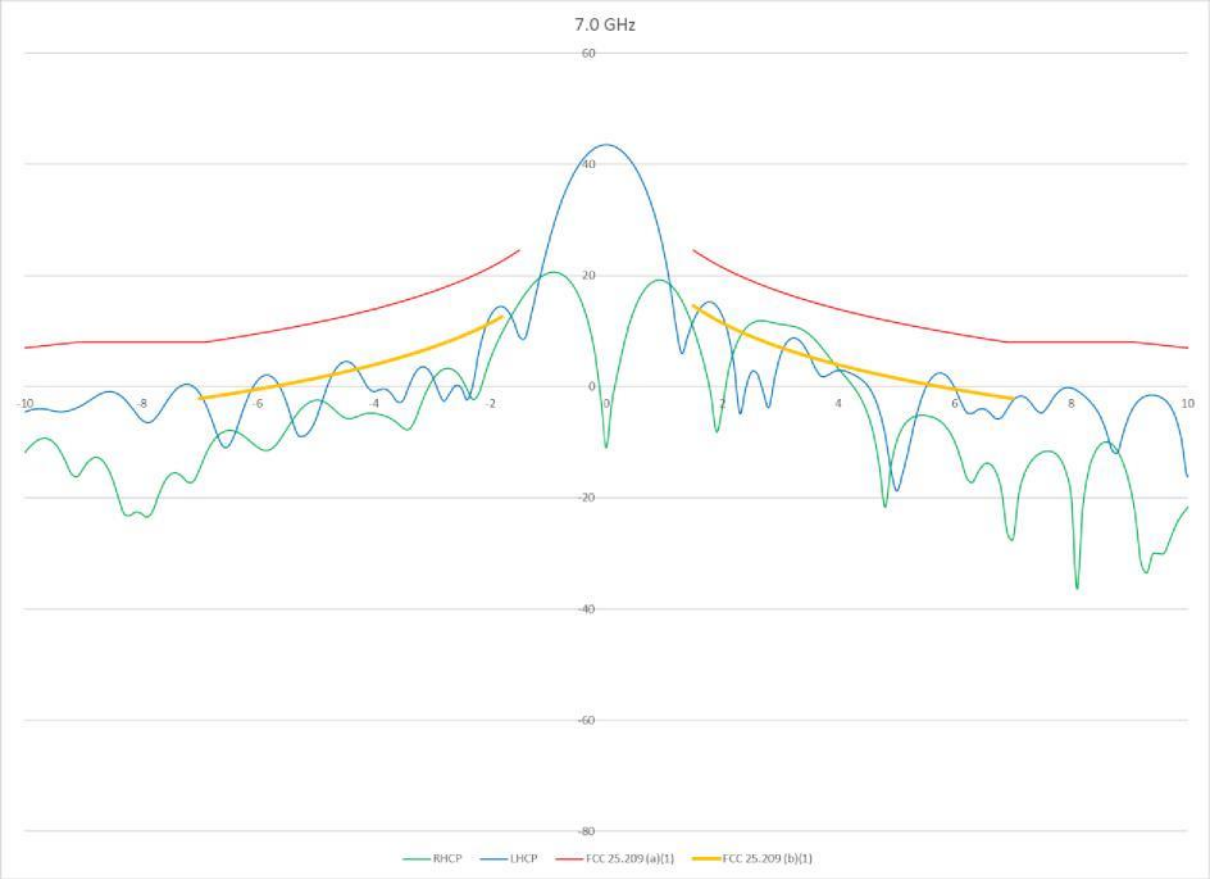
In looking at the Predictive pattern, we see the following:



From the co-polarized standpoint, we are in total compliance with the specification. There are a few minor excursions over the curve, but all are within the 3 dB limit and 10% as specified.

For the Cross-polarized pattern there is a minor excursion on the right side of the pattern, see below:

We expect this to be caused from the struts reflections and may not be as pronounced on the actual delivered antenna.



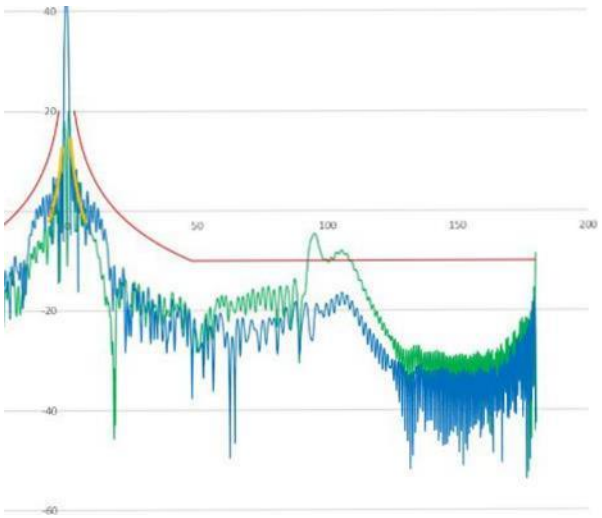
Additionally, for the Elevation Patterns we used paragraph 25.209 (a)(4) for co-polarized patterns and 25.209(b)(2) which state the following:

> In the plane perpendicular to the GSO arc, as defined in § 25.103, for earth stations not operating in the conventional Ku-band, the 24.75-25.25 GHz band, or the 28.35-30 GHz band:
>
> Outside the main beam, the gain of the antenna shall lie below the envelope defined by:
>
> $32-25\log_{10}\theta$ dBi for $3° < \theta \leq 48°$.
> -10 dBi for $48° < \theta \leq 180°$.
>
> Where θ and dBi are as defined in paragraph (a)(1) of this section. This envelope may be exceeded by up to 6 dB in 10% of the range of θ angles from ±3-180°, and by up to 6 dB in the region of main reflector spillover energy.
>
> In the plane perpendicular to the GSO arc, for earth stations not operating in the 24.75-25.25 GHz or 28.35-30 GHz bands:
>
> $19-25\log_{10}\theta$ dBi for $3° < \theta \leq 7°$.

Again, the co-polarized pattern is completely compliant and the cross polarized patterns has minor excursions as shown below.

7.0 GHz

6 0



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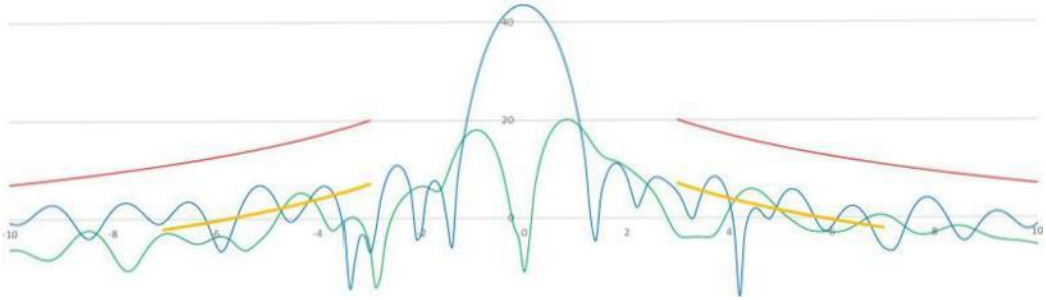
7.0 GHz

e o



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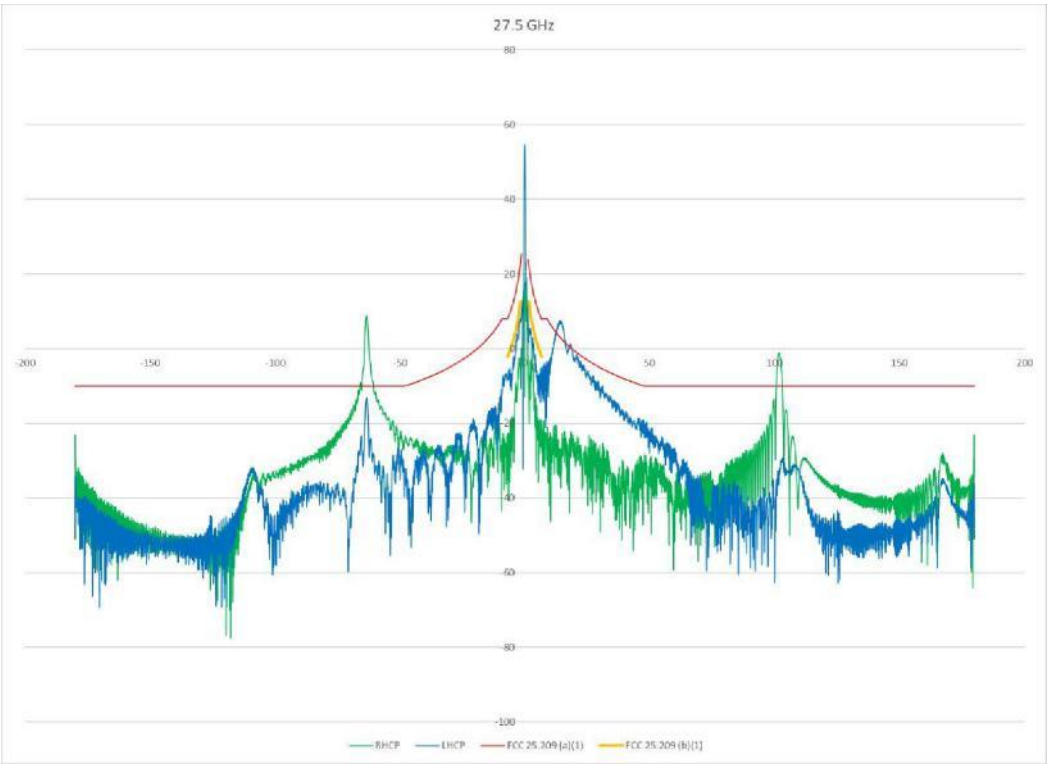
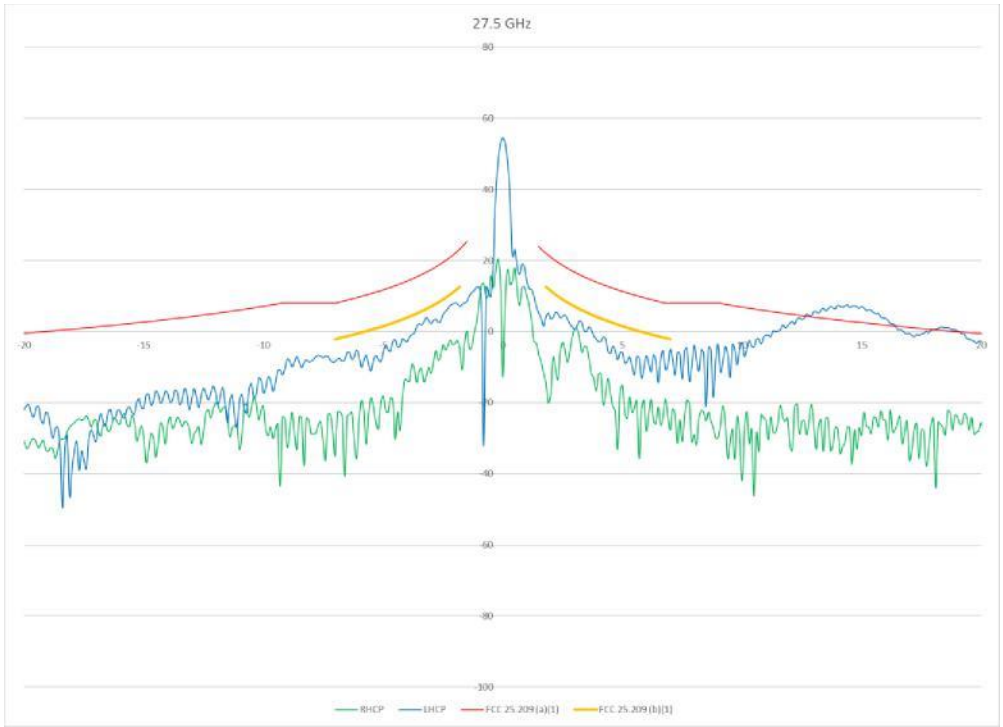
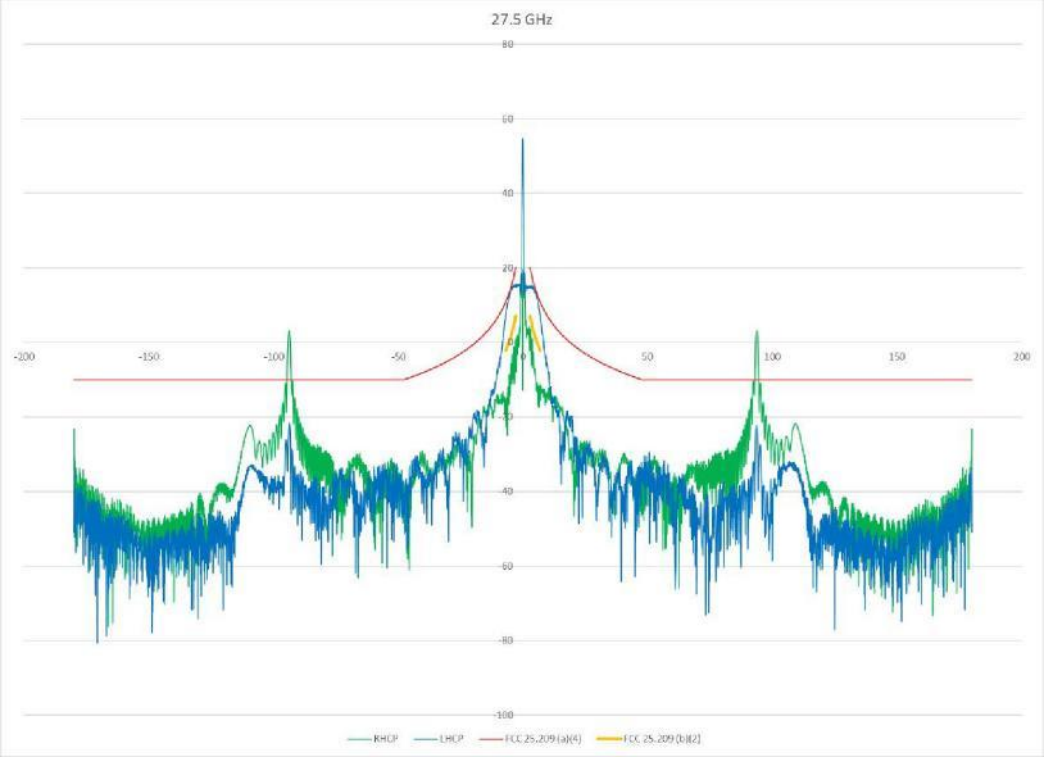
-R0(P -WC, -FCC 25.209(4⁶) --4(C 75.2060)01

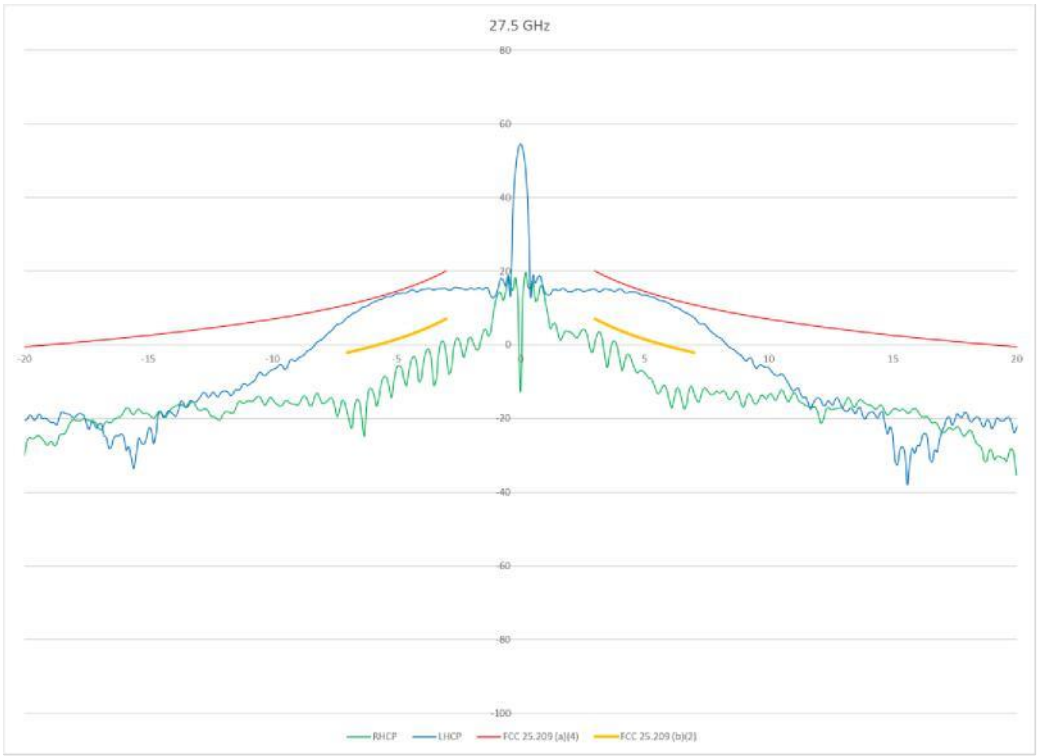
For the Ka Band there are multiple paragraphs that are applicable to assess the performance against these requirements. First for transmitting between 27.5 – 28.35 GHz and 30 – 31 GHz we assessed co- polarized performance against 25.209 (a)(1) and cross polarized performance versus 25.209 (b)(1) as before. See plot below:





For this the cross polarized pattern is totally compliant, but the co-polarized pattern does have an excursion that exceeds the mask by 4 dB versus the 3 dB allowed; however the pattern is well within the 10% allowance. For the Elevation Pattern again, we used paragraph 25.209 (a)(4) for co-polarized patterns and 25.209(b)(2). See below for performance, both compliant.





For the frequencies between 28.35 – 30 GHz, the specifications change for co-polarized patterns, 25.209(a)(3) states:

In the plane tangent to the GSO arc, for earth stations operating in the 24.75-25.25 GHz or 28.35-30 GHz bands:

29-25log$_{10}$0	dBi for 2° ≤ 0 ≤ 7°.
8	dBi for 7° < 0 ≤ 9.2°.
32-25log$_{10}$0	dBi for 9.2° < 0 ≤ 19.1°.
0	dBi for 19.1° < 0 ≤ 180°.

Where 0 and dBi are as defined in paragraph (a)(1) of this section. This envelope may be exceeded by up to 3 dB in 10% of the range of 0 angles from ±7-180°, and by up to 6 dB in the region of main reflector spillover energy.

For co-polarized in the other plane, 25.209(a)(6) states:

In the plane perpendicular to the GSO arc, for earth stations operating in the 24.75-25.25 GHz or 28.35-30 GHz bands:

Outside the main beam, the gain of the antenna shall lie below the envelope defined by:

32-25log$_{10}$0	dBi for 3.5° < 0 ≤ 7°.
10.9	dBi for 7° < 0 ≤ 9.2°.
35-25log$_{10}$0	dBi for 9.2° < 0 ≤ 19.1°.
3	dBi for 19.1° < 0 ≤ 180°.

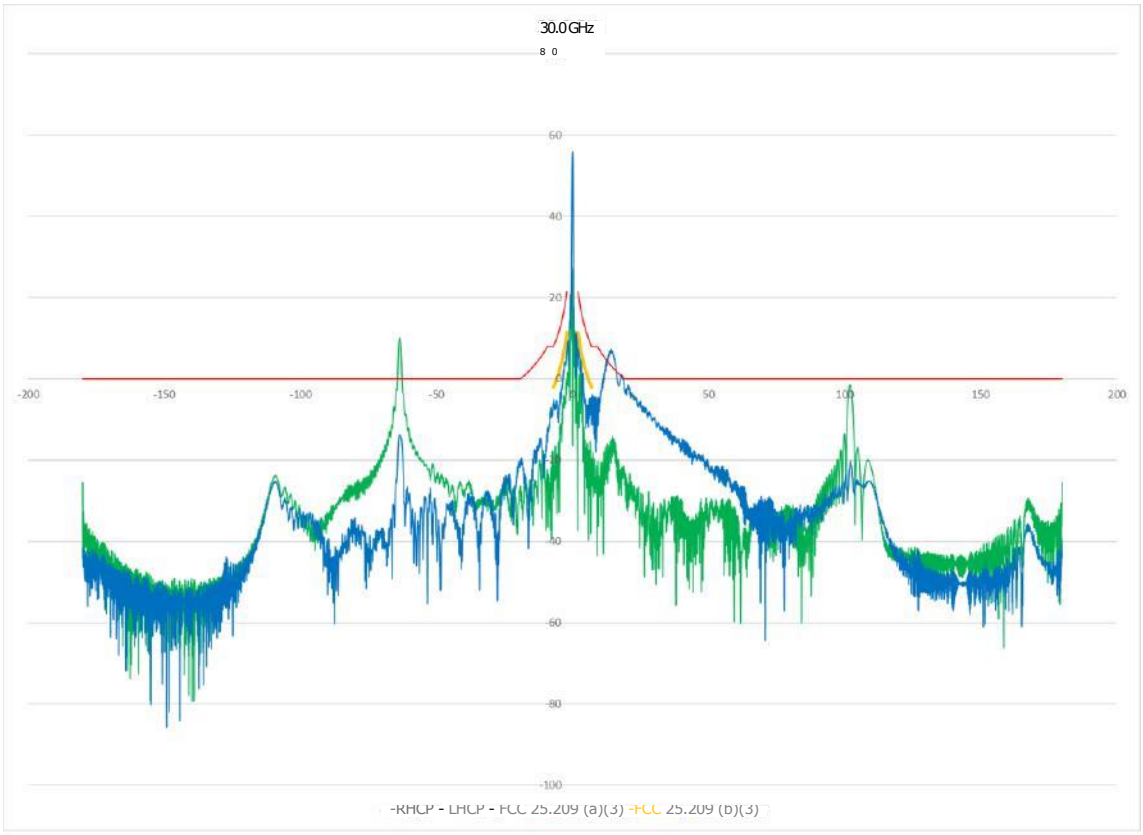
Where 0 and dBi are as defined in paragraph (a)(1) of this section. This envelope may be exceeded by up to 6 dB in 10% of the range of 0 angles from ±3-180°, and by up to 6 dB in the region of main reflector spillover energy.

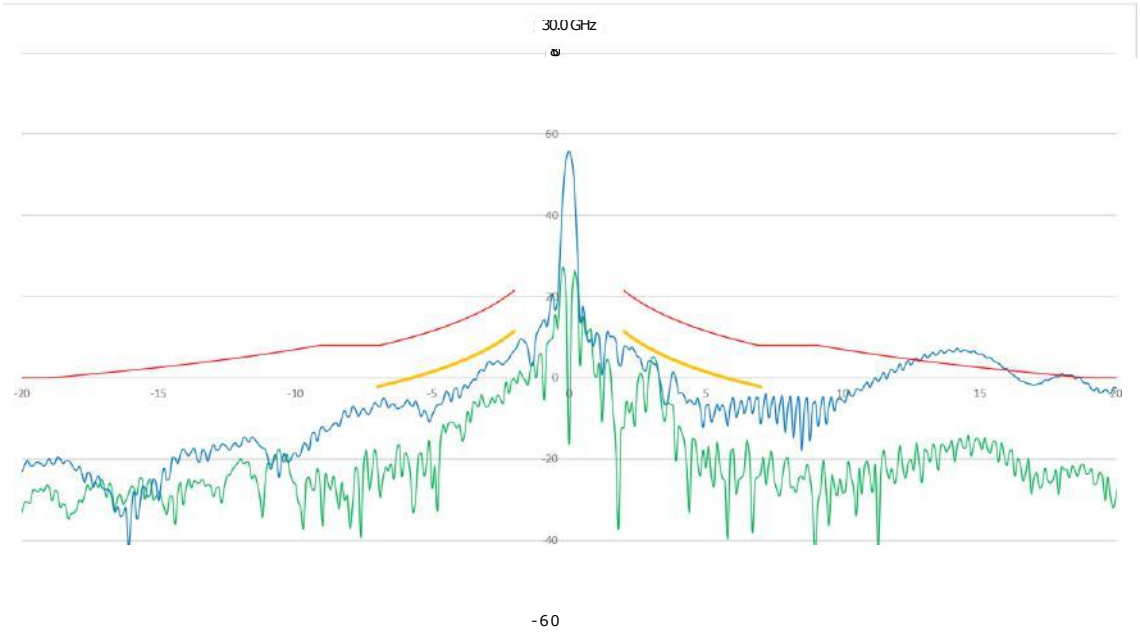
For cross-polarized patterns, the same paragraph is used for both planes 25.209(b)(3):

In the plane tangent to the GSO arc or in the plane perpendicular to the GSO arc, for earth stations operating in the 24.75-25.25 GHz or 28.35-30 GHz bands:

19-25log$_{10}$0	dBi for 2° < 0 ≤ 7°.

Below are the plots against these requirements. It shows again a minor excursion on the Azimuth plane in co-polarized operation but all other are completely compliant.





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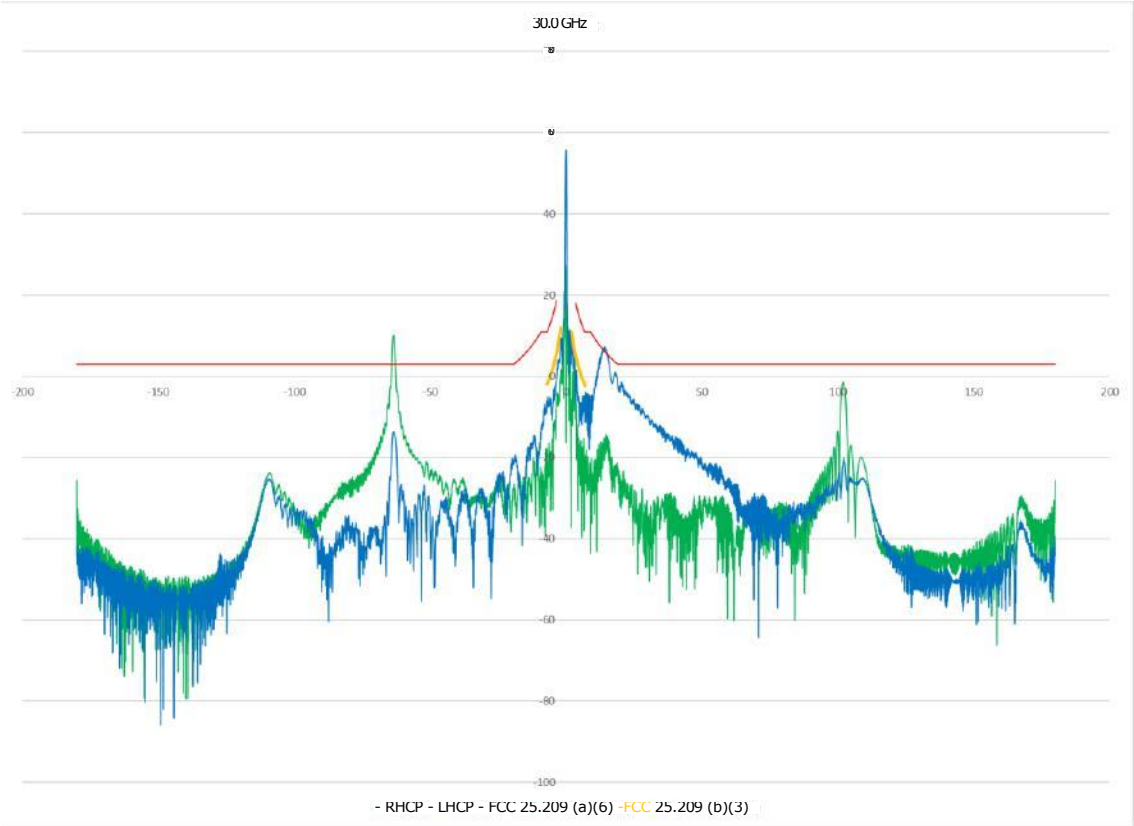
-100

-RHCP - LHCP - FCC 25.209 OW) -FCC 25.209 (b)(3)


30.0 GHz
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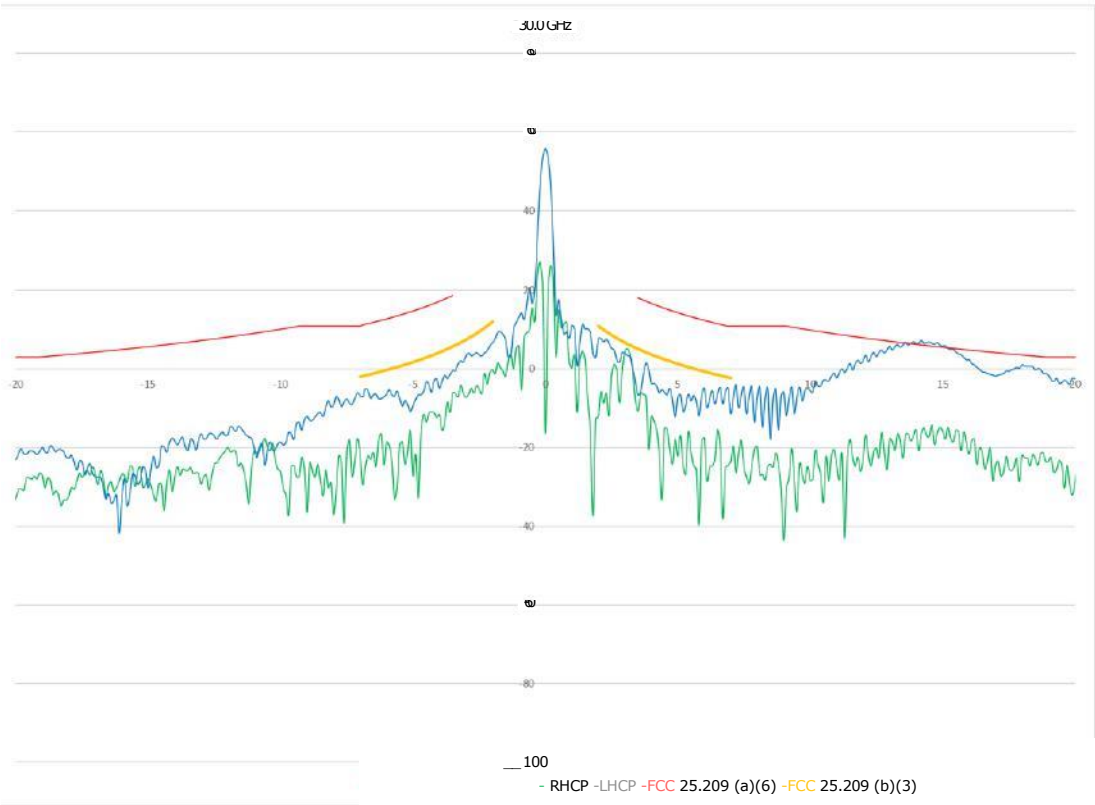
-200
-150
-100
-50
50
100
150
200
-40
-60
-80
-100
- RHCP - LHCP - FCC 25.209 (a)(6) -FCC 25.209 (b)(3)


30.0 GHz
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-20
-40
-80
__100
- RHCP -LHCP -FCC 25.209 (a)(6) -FCC 25.209 (b)(3)

As stated above, the FCC does not have firm requirements for the performance of antennas being used with NGSO systems. The requirement is simply to get concurrence from the satellite system being used. However, in trying to gauge the performance of the antenna versus the traditional requirements for operation on GSO systems, the antenna patterns show some minor excursions compared to the specifications as laid out in the requirements. The other issue with these patterns being used for this type of coordination is that they may not accurately represent the actual performance when mounted to an X/Y positioner. As the X/Y positioner moves the antenna in Azimuth and Elevation, the orientation of the reflector and struts rotates as it moves. As such, there is not a single cut of the antenna pattern that can define the actual pattern performance for all GSOs. We have essentially taken the worst-case scenario with the orientation of the struts used within the analysis of the antenna. Furthermore, the patterns do not take into account adding absorbers to the struts, which the antenna struts will have.

Conclusion:
Comtech supports with a high level of confidence that the transmit operations based on the data provided is acceptable for FCC compliance. Should there be an issue, there are other analysis methods to prove compliancy. Paragraph 25.209(f) provides for use of 25.218 to define the EIRP spectral density curve, which is based on the power level and modulation of the signal to be potentially radiated. Due to the minor nature of the excursions over the curve, the antenna would be able to show compliance to this with a very small data signal. The issue with use of this approach is that there are no performance specification for the frequency range of 7.0 – 7.25 GHz or for 27.5 – 28.35 GHz, or 28.6 – 29.25 GHz or 30 – 31 GHz, so it is unclear what exact performance standard could, or should, be applied to verify performance. In the 30 – 31 GHz range, verification could possibly be covered by the MIL Standard covering those frequencies.

Comtech believes that this antenna is fit for purpose and will support in any way necessary to achieve authorization to use.

Sincerely,

Mark Cavalier
Group Vice President, Systems Engineering
Comtech Space Components and Antennas