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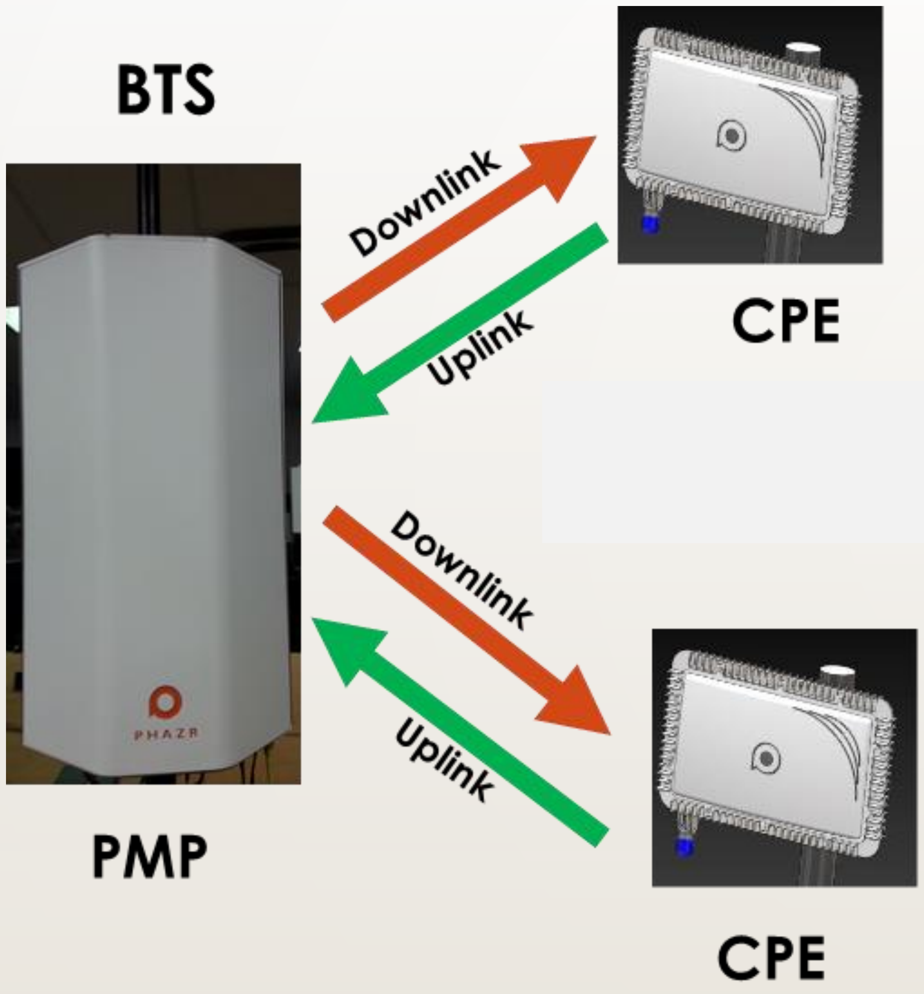
Proposed FCC Part 30 Test Method for RABACK (BTS) 28GHz mmW Transmitter

June 26, 2018

Phazr Quadplex System – Fixed Wireless Access System Overview



The Phazr fixed wireless access (FWA) system consists of RABACK (BTS) and multiple GAZERs (CPEs)

Basestation 28GHz Transmitter Description

The purpose of the proposed test method for FCC Part 30 for the 28GHz mmW transmitter is to make sure our design verification test procedure at our lab is acceptable by FCC and consistent with the test method used at the TCB test lab.

The RABACK Base Station (BTS) consists of:

4 Downlink 28GHz mmW Transmitter chains with 2 integrated vertical polarization antennas and 2 integrated horizontal polarization antennas.

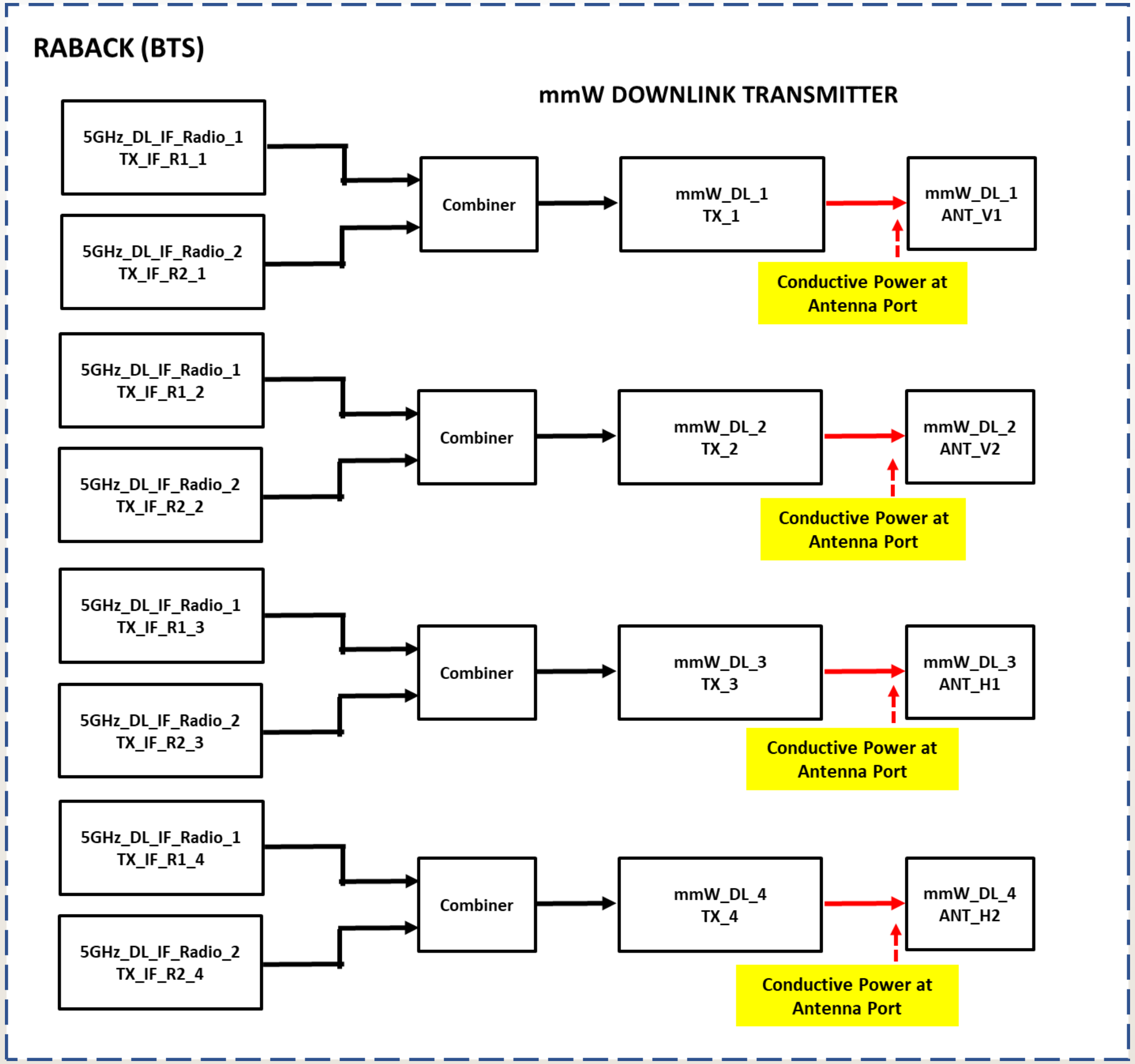
4 Uplink 5GHz Receiver chains with 2 integrated vertical polarization antennas and 2 integrated horizontal polarization antennas.

The GAZER Customer Premises Equipment (CPE) consists of:

2 Downlink 28GHz mmW Receiver chains with 1 integrated vertical polarization antenna and 1 integrated horizontal polarization antenna.

4 Uplink 5GHz Transmitter chains with 2 integrated vertical polarization antennas and 2 integrated horizontal polarization antennas.

RABACK (BTS) High Level Block Diagram and Proposed Test Method for 28GHz mmW Downlink TX



Our current RABACK (BTS) product have four integrated 28GHz mmW antennas.

Part 30.203 Emission Limits (a) specifies that "The conductive power or the total radiated power of any emission outside a licensee's frequency block shall be -13dBm/MHz or lower. …"

Our partner Met Lab informed us that the "total radiated power" (TRP) test method has not been fully finalized by ANSI yet. Therefore, at Phazr, we proposed to use the "conductive power" derived from the antenna gain to show compliance to Part 30.203 and Part 30.404.

Proposed 28GHz mmW TX Test Method:

- Perform TX radiated tests at 3 meters for Transmit EIRP.
- Provide the integrated 28GHz mmW Vertical Antennas and 28GHz mmW Horizontal Antennas Gain Test Results and Antenna Patterns Info.
- Derive TX conductive power at the antenna port by using the measured Transmit EIRP minus the known antenna gain.
- Use the derived TX conductive power test results to show compliance to Part 30.203 and Part 30.404.

Please let us know if the proposed conductive test method is acceptable to FCC.

If not, please suggested a test method that we can perform before taking our product to TCB test lab for certification tests for Part 30.

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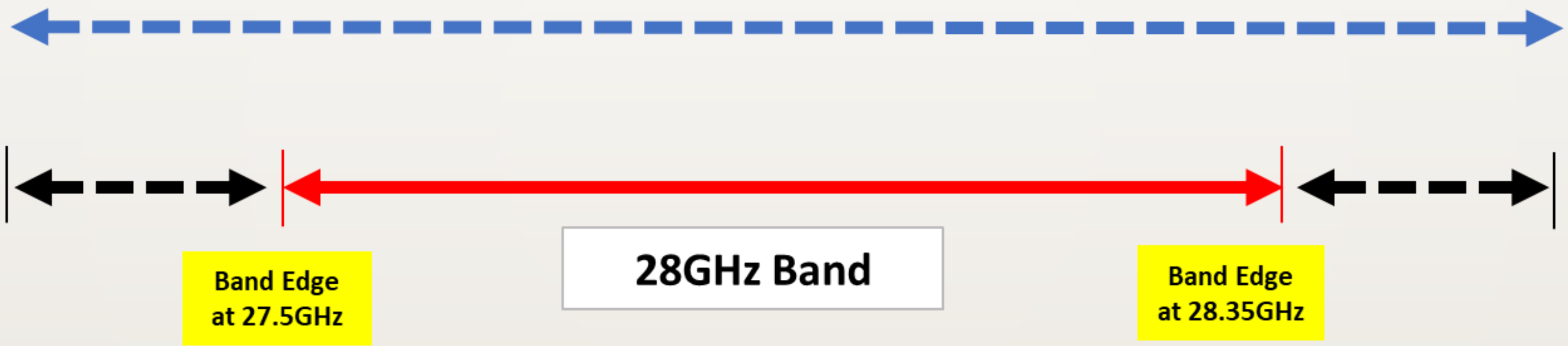
RABACK (BTS) High Level Block Diagram and Proposed Test Method for 28GHz mmW Downlink TX

Calculate Conductive Power from Radiated Power and Antenna Gain in the Region where:

Frequency Range where Antenn Gain with VSWR < 2:1 (RL < 9.5dB)



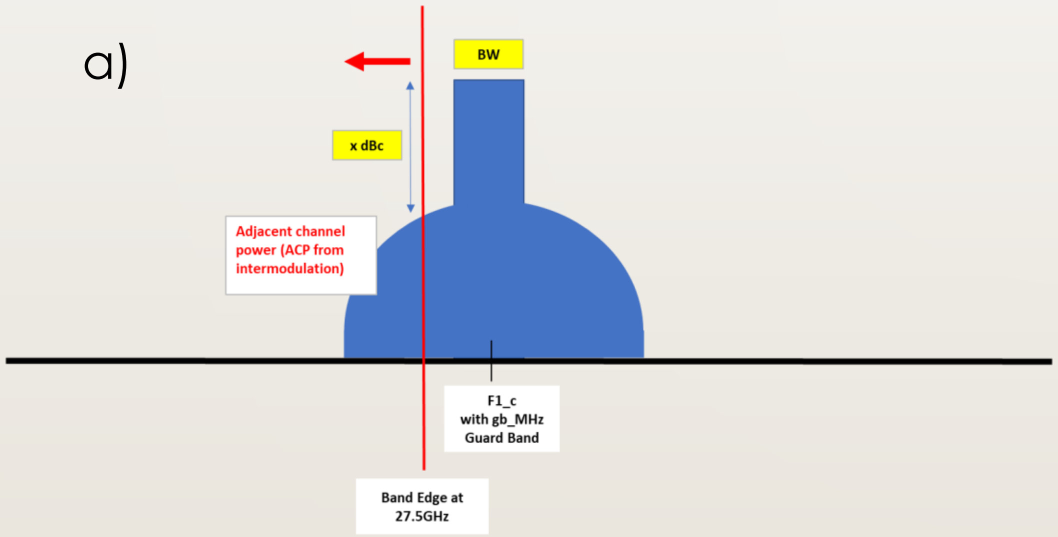
RABACK (BTS) High Level Block Diagram and Proposed Test Method for 28GHz mmW Downlink TX

FCC Question:
Please provide justifications for why you believe subtracting antenna gain from radiated power (EIRP) will provide accurate theoretical conducted power (especially in out of band regions). Radiation pattern of antennas are most likely function of frequency and may considerably change as we move further away from designed frequency.

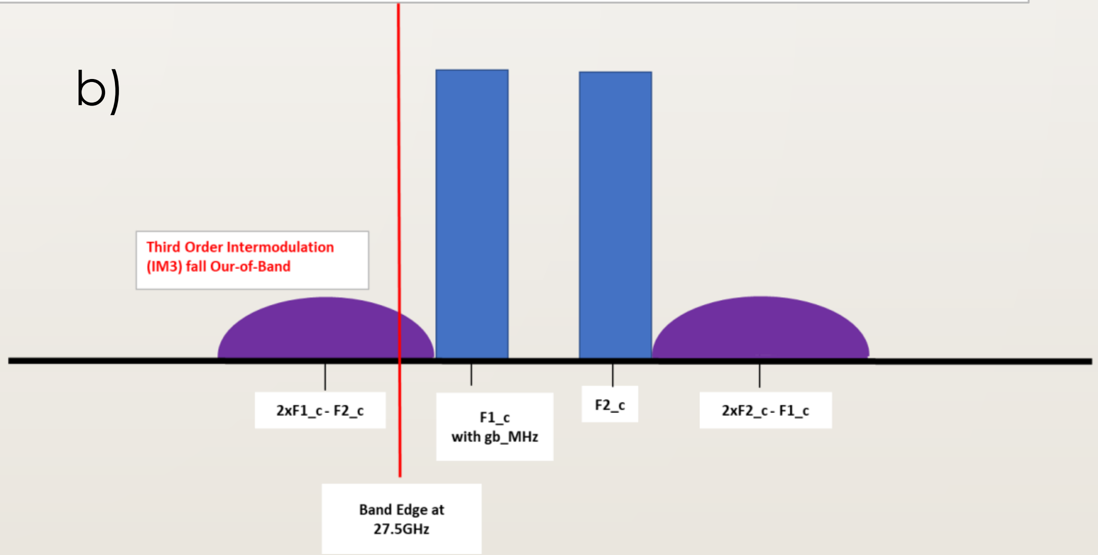
Phazr Response:
Conductive power calculation only applies to the desired signal power and the unwanted spurious emissions near the band edges. At this region, the antennas have VSWR ≤ 2:1 (Return Loss better than 9.5dB) so that the conducted power calculation should be reasonably accurate. Outside of the antennas VSWR ≤ 2:1 region, use the radiated spurious emissions.

In our system, the worst unwanted emissions occur near band edge are from
a) Adjacent channel power from the desired transmit signal near band edge
b) Third order intermodulation of the two desired transmit signals

a)



b)



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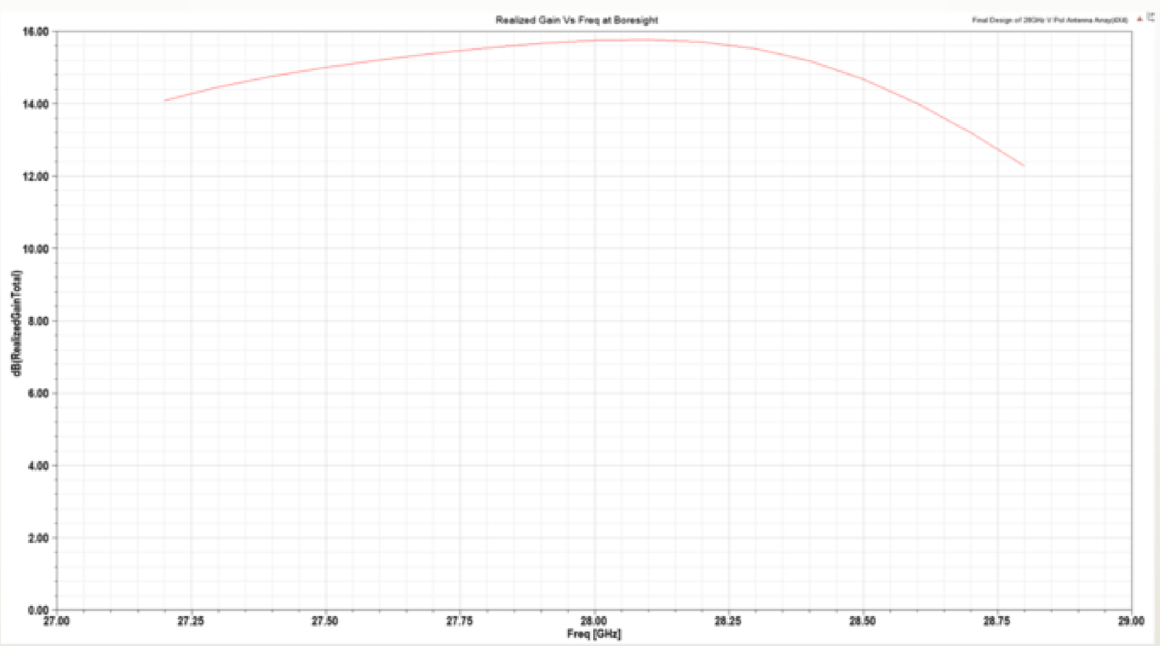
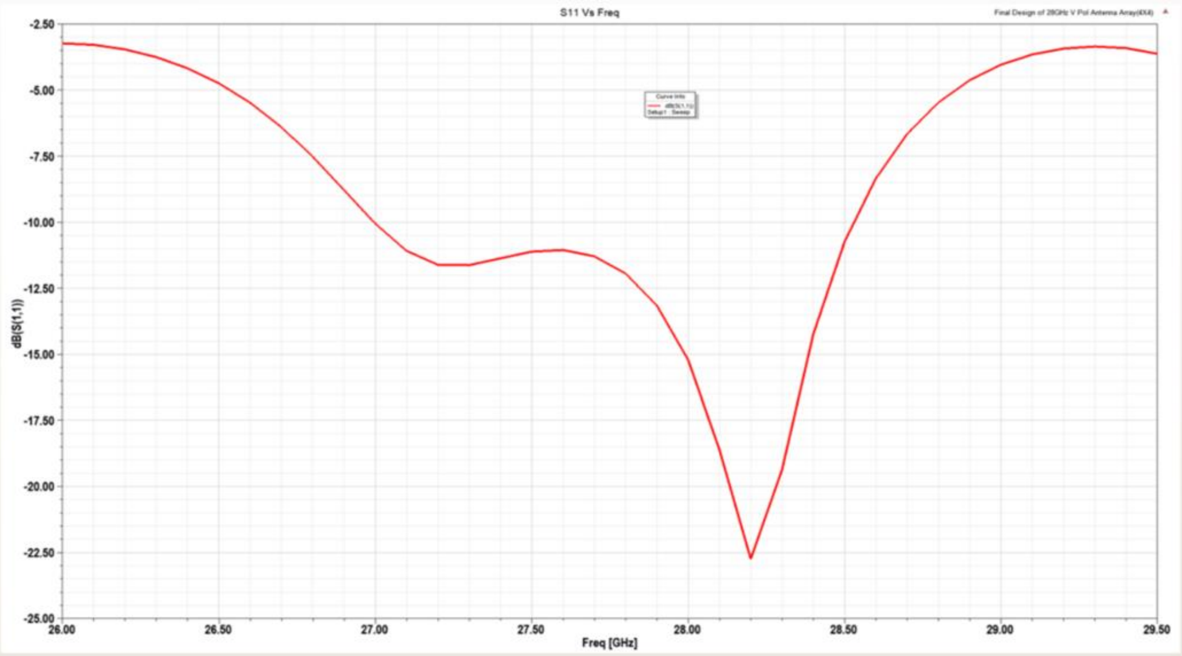
Antenna Gain vs Frequency Example

<u>FCC Question:</u>
Please indicate if you are prepared to provide radiation pattern of each antenna as a function of frequency in your subsequent correspondence in addition to requested information above

<u>Phazr Response:</u>
Yes, we will be providing measured data (gain vs frequency) when we go through certification testing. See <u>design simulation</u> example below.





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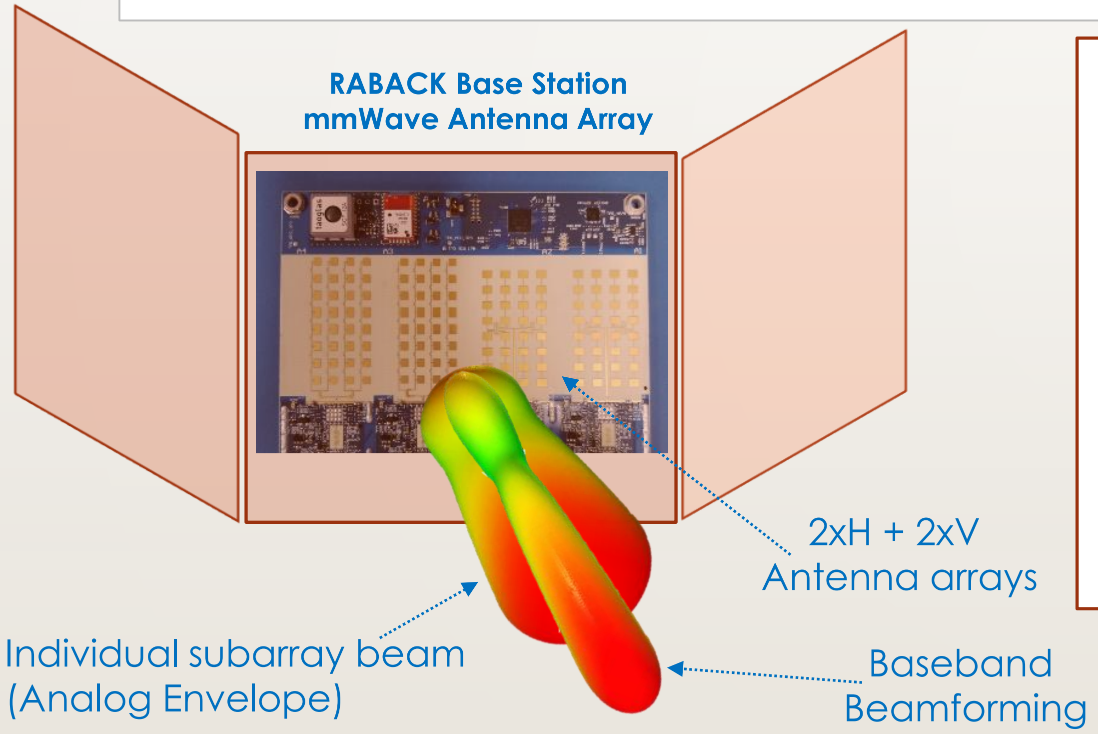
Raback (BS) Antenna System

FCC Question:
Please provide a detailed description of your antenna systems and RF performance of RABACK base station and GAZER customer premises equipment so further guidance can be provided. In your description please provide characteristics of each antenna (type of antennas and their radiation patterns for both vertical and horizontal polarizations), their phase relationships, ability to create and radiate single or multiple beams, steerability of each beam and probability of overlap (if beams can in fact be steered)

Phazr Response:
RABACK Base Station antenna & GAZER CPE antenna systems are described below and in next slide.



- Each RABACK has three 40 degree subsystems, providing120 degree coverage
- In each 40 degree sector, there are 4 antenna arrays…
- 2x H-Pol and 2x V-Pol, corresponding to 4 RF Transmit chains
- Each of the four antenna arrays have 32 antenna elements, all belongs to a single RF transmitter chain
- Each subarray create the outer analog envelope as shown in the illustration[1]
- Phazr RABACK/GAZER system has digital (baseband) beam forming that further increases the gain as shown in the inner lobe in the illustration
- There is no Phase shift or beam steering applied

NOTE: 1 – Beam shown in diagram is for illustration, not the actual antenna pattern

Raback (BS) Antenna System

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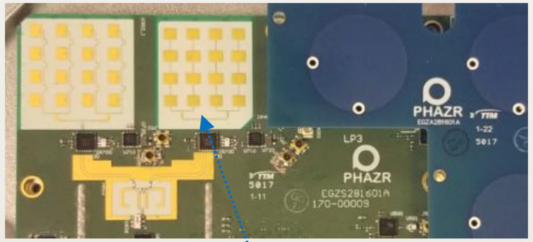
Please provide a detailed description of your antenna systems and RF performance of RABACK base station and GAZER customer premises equipment so further guidance can be provided. In your description please provide characteristics of each antenna (type of antennas and their radiation patterns for both vertical and horizontal polarizations), their phase relationships, ability to create and radiate single or multiple beams, steerability of each beam and probability of overlap (if beams can in fact be steered)

Phazr Response:
RABACK Base Station antenna & GAZER CPE antenna systems is described below and in next slides.

GAZER CPE
mmWave Antenna Array



1xH + 1xV Antenna arrays

- Note that GAZER does NOT transmit in mmWave (only receives in mmWave and Transmit in 5GHz band)
- In each GAZER, there are 2 mmWave antenna arrays…
- 1x H-Pol and 1x V-Pol, corresponding to 2 RF Receive chains
- Each of the four antenna arrays have 16 antenna elements, all belongs to a single RF receiver chain
- Phazr RABACK/GAZER system has digital (baseband) beam forming and GAZER provide channel information to RABACK to aid in digital beam forming

Request From FCC (4/13/2018)

…given, part 30 devices are relatively new technology, we still require more detailed description of your devices including details of their beamforming technology. Please note that this device is considered capable of multi beam operation since there are more than one transmitters (per polarization) in the base station even though each transmitter only creates one polarized beam.

Additionally, since you are pursuing an alternative method to TRP measurement (to verify compliance to emission requirements in the band edge), we will need to review the measured gain of your antenna systems and the details of your calculation of conducted power based on radiated power and antenna gain. In your analysis, please provide gain of the antenna as a function of frequency as well as associated losses due to impedance mismatches and efficiency of the antenna. Finally, please note that your suggested method is currently only acceptable in the band edge of assigned block and not in the spurious domain.

6/21: Explanation of Beamforming Operation

FCC Question:
(Note: This is a follow-up question from the FCC)

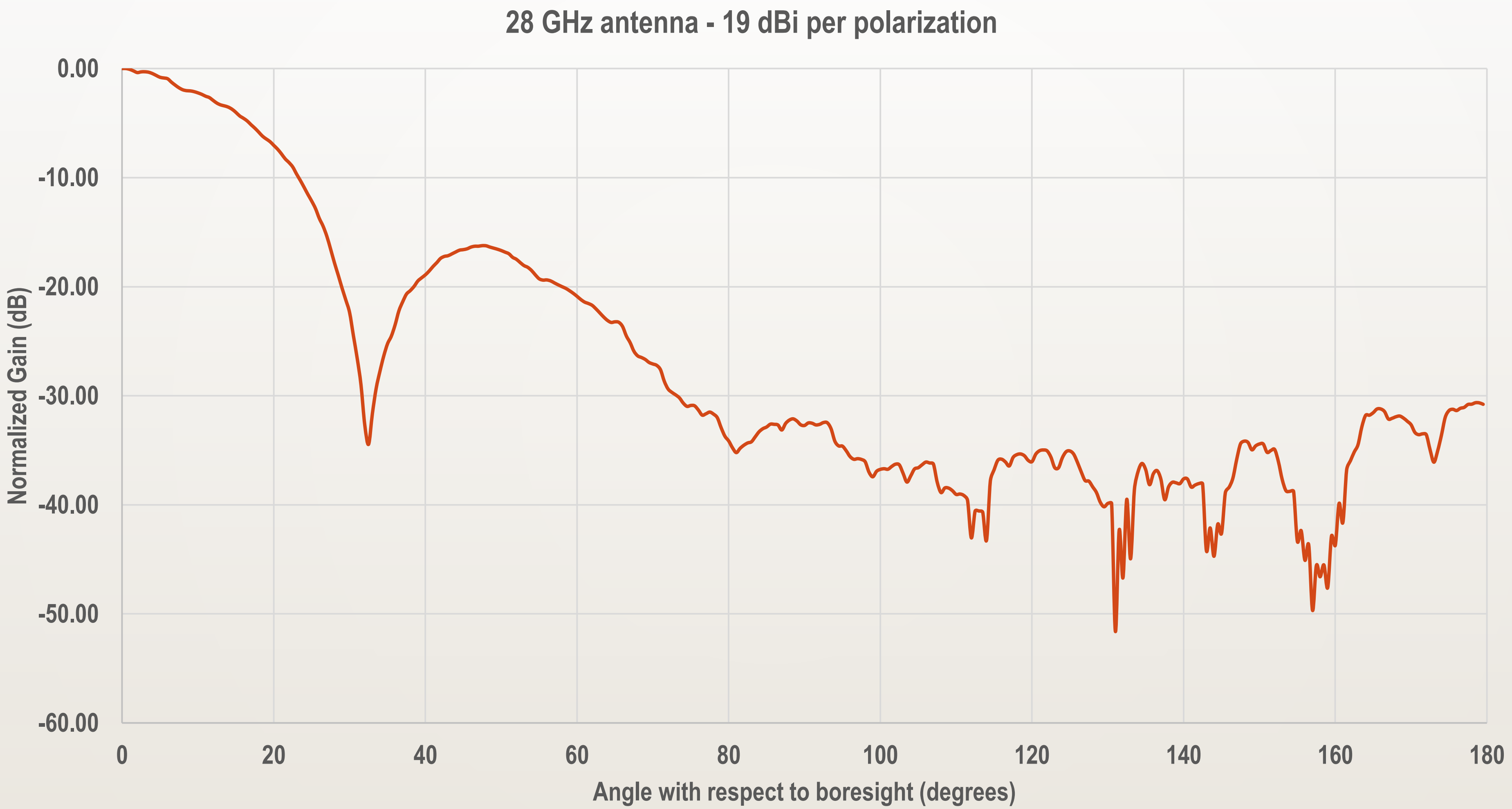
… Part 30 devices are relatively new technology, we still require more detailed description of your devices including details of their beamforming technology

Phazr Response:

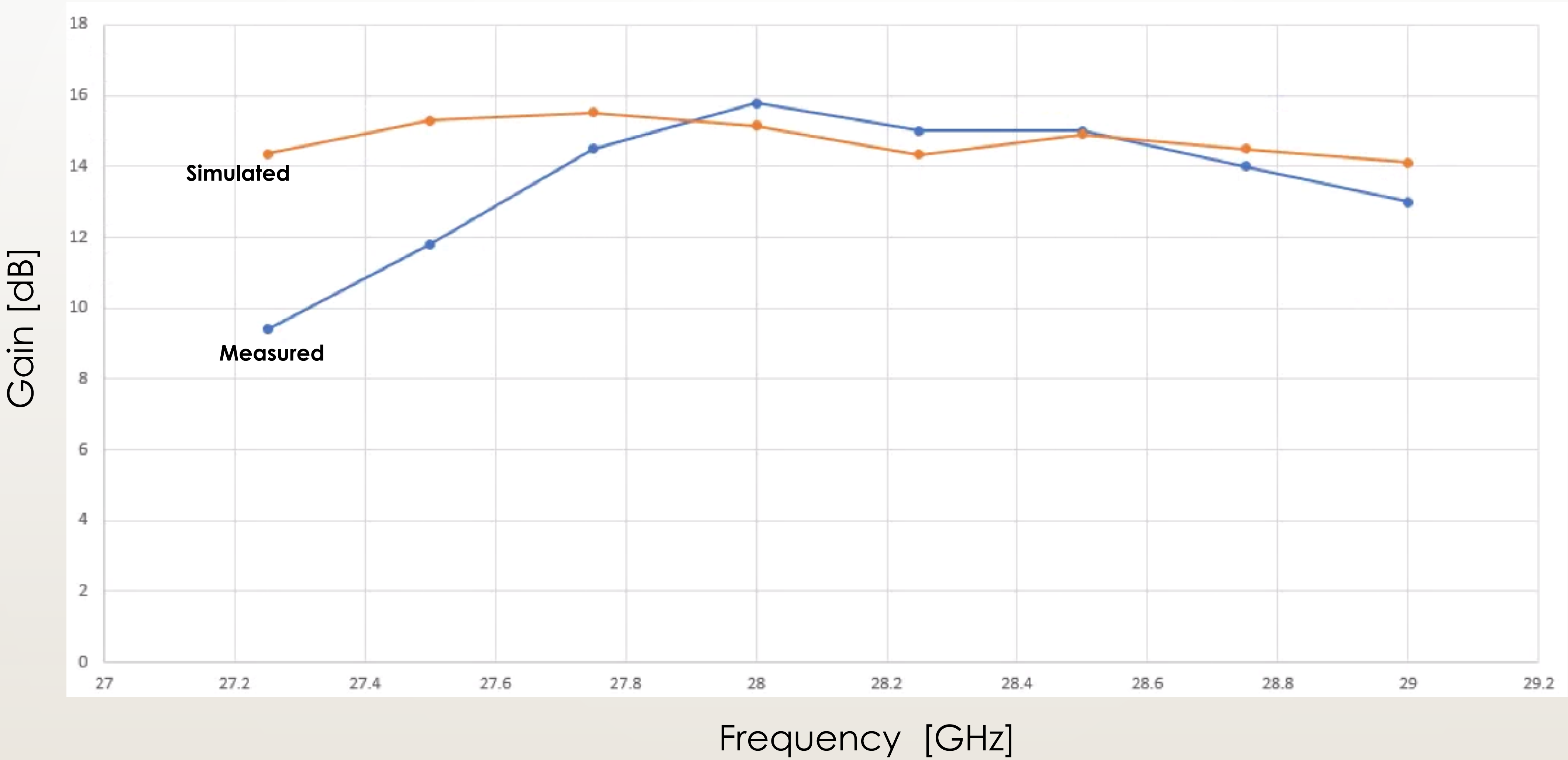
Beamforming operation in the Phazr system is described below.

- The RABACK, which is Phazr's Base Station Unit consists of 3 Hypercores.
  - Each Hypercore provides radio coverage over 40° (azimuth) using a fixed analog beam.
  - The analog beam patterns (Azimuth and Elevation), as well as the antenna gain, as a function of frequency, has already been provided.
  - Each Hypercore comprises two cores (each core is a Wi-Fi SoC (comprising baseband + RF functions integrated as a single chip SoC)
  - Both the cores share a single RFFE (RF Front End) and antenna panels.
- Beamforming in Phazr system is fully digital (i.e. no analog beamforming).
- Phazr system being certified consists of 4 RF chains per Hypercore (2 dedicated to V-Pol and 2 dedicated to H-Pol).
- The highest EIRP case occurs during a single stream transmission to a CPE (where all 4 chains are utilized to beamform to a single CPE, resulting in an additional max. beamforming gain of 12 dB)
  - During a 2 stream transmission, a max. beamforming gain of 6dB per Pol. can be assumed.
- Phazr system uses the explicit beamforming mode described in the IEEE 802.11ac specifications, wherein the transmitter (which can be the BS or the CPE) sends training data to the receiver. The receiver in turn, explicitly feeds back information that is utilized by the transmitter for precoding.

6/25: Measured Antenna Gain Pattern



6/26: Measured (and simulated) Antenna Gain vs Frequency – V-Pol



Note : Accuracy of the measured data is within 1 dB, given the uncertainties involved in the test setup

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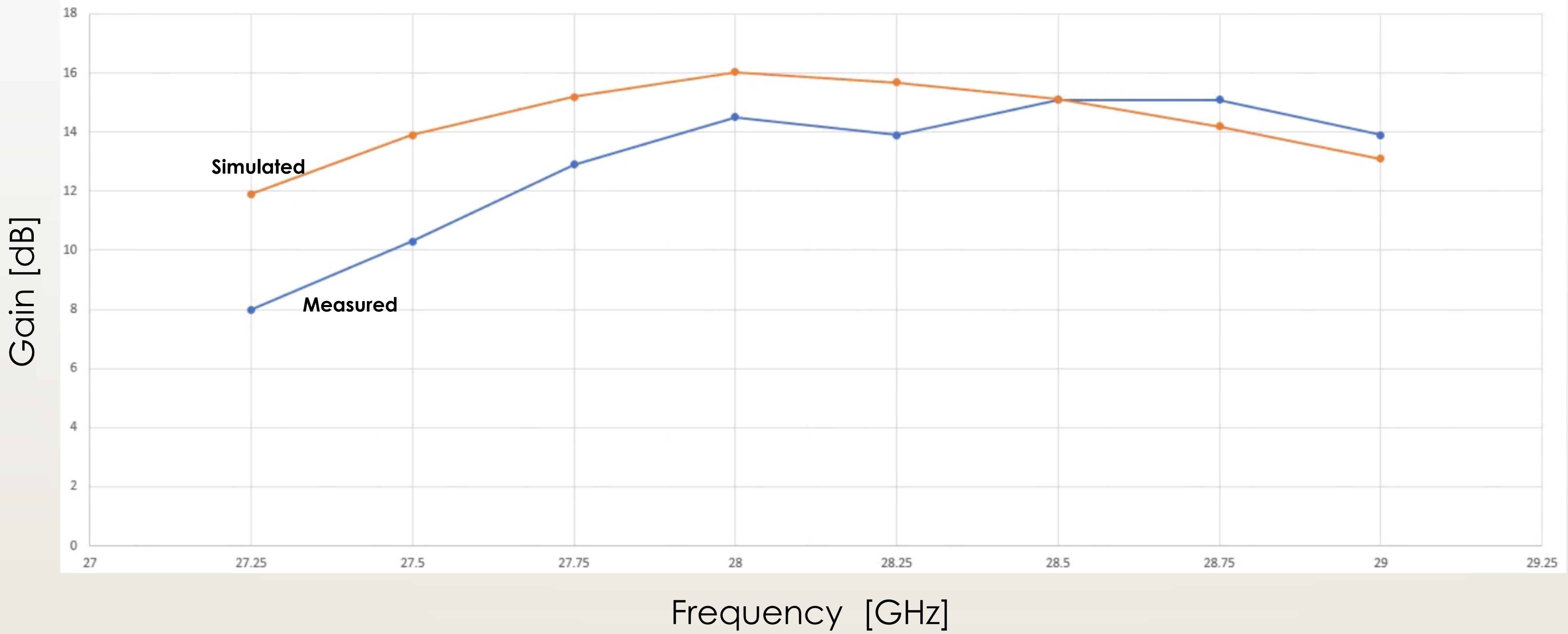
6/26: Measured (and simulated) Antenna Gain vs Frequency – H-Pol



Note : Accuracy of the measured data is within 1 dB, given the uncertainties involved in the test setup