

Audi PPE Roof-Antenna C-Sample Datasheet

20.08.2021

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Fuba Electrical Engineering

Documentation Of Changes

Date	Chapter	Changes	Author
20.08.2021	1-4	Initial Version	M. Schultz

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1. Overview



1. Overview

- In this datasheet the typical performance of the PPE antenna-module at C-sample-stage is given.
- Data is shown for all three versions (E: 2xGNSS+CV2X, A: 1xGNSS, B: SDARS)
- The PCBs are machine-populated and the mechanics are from series-tool-parts.

The subsequently referenced variants are:

- **Fuba Part Number:** 30006192 ANT-ASM, AU-PPE,2TE,GNSS,BT,CV2X **Customer Part Number:** 85E 035 503 **E**
- **Fuba Part Number:**30006191 ANT-ASM, AU-PPE,2TE,GNSS,BT,SD **Customer Part Number:** 85E 035 503 **B**
- **Fuba Part Number:** 30006034 ANT-ASM, AU-PPE,2TE,GNSS,BT **Customer Part Number:** 85E 035 503 **A**



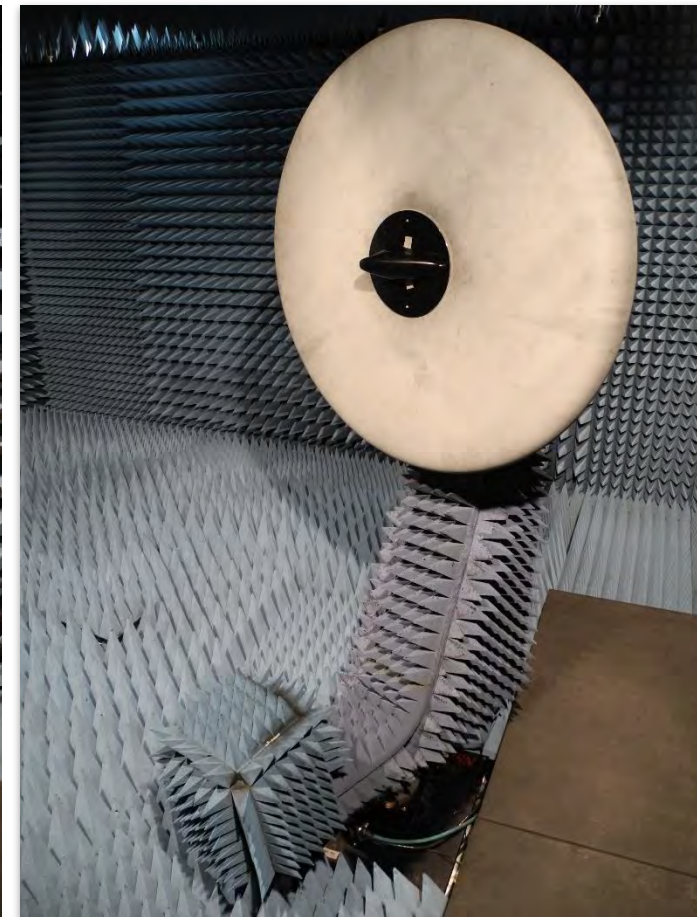
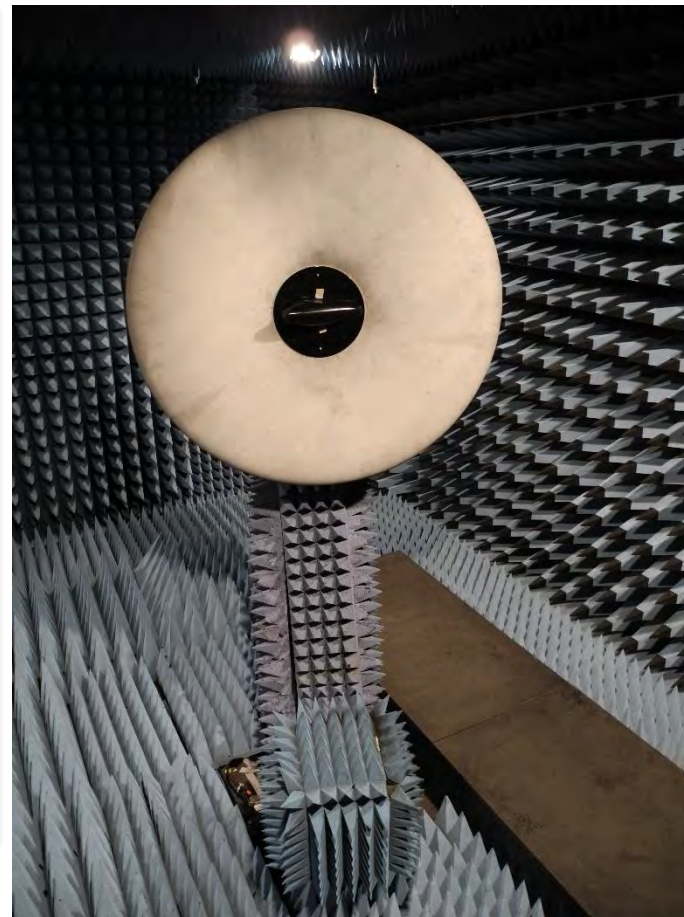
1. Overview

- Measurements were done in anechoic chamber.
- A rounded-edge groundplane was used with the antenna under test (AUT) placed on an adapter-plate (which models the roof-surface and –cutout) in the center of the rounded-edge-groundplane.
- All depicted field-data is farfield data calibrated to dBi.
- All antennas are passive and measured past matching-networks at the Fakra-position. All non-stimulated antennas are terminated with 50Ohms.



1. Overview

Anechoic Chamber with AUT



2. Data Variant E

2xLTE, 2xGNSS, BT, CV2X

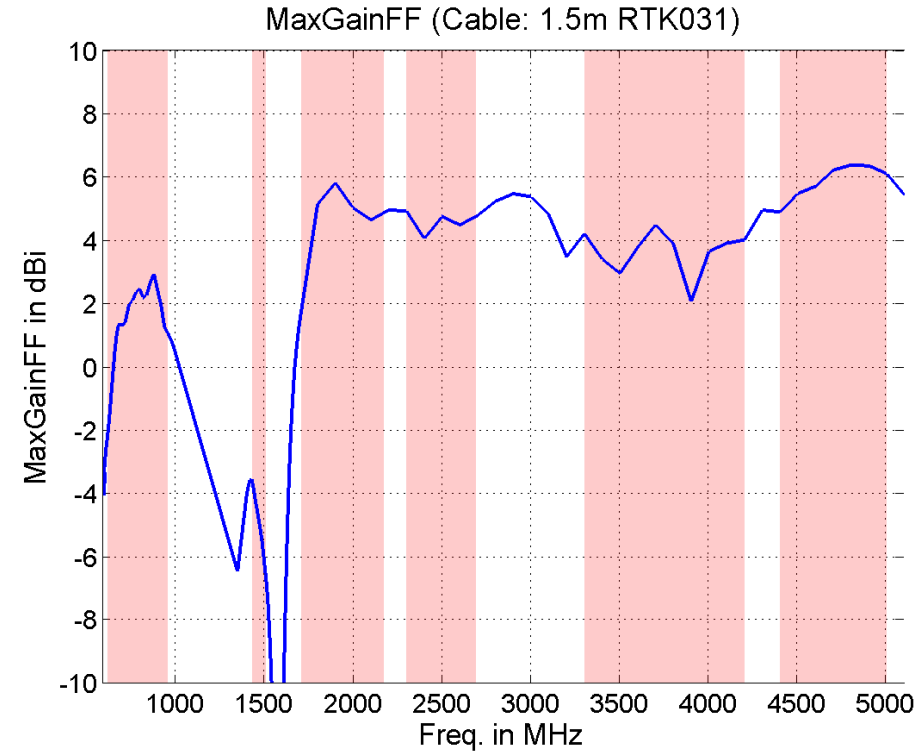
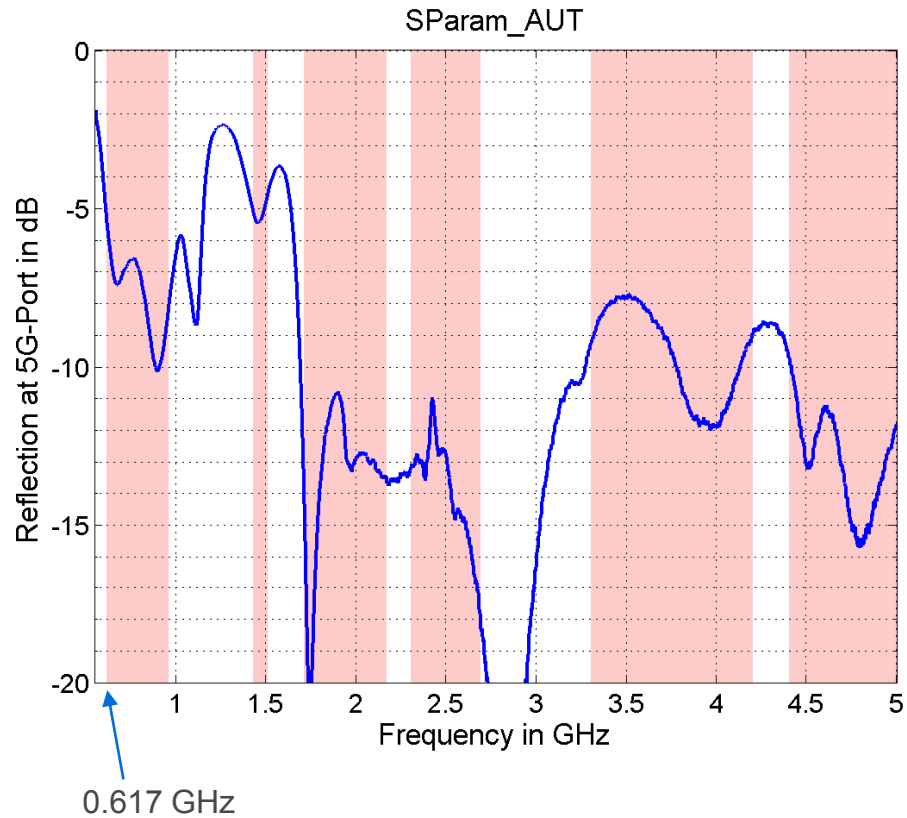


2.1 LTE Front (LTEf)



2.1 Variant E: LTE Antenna Performance Matching (LTE front)

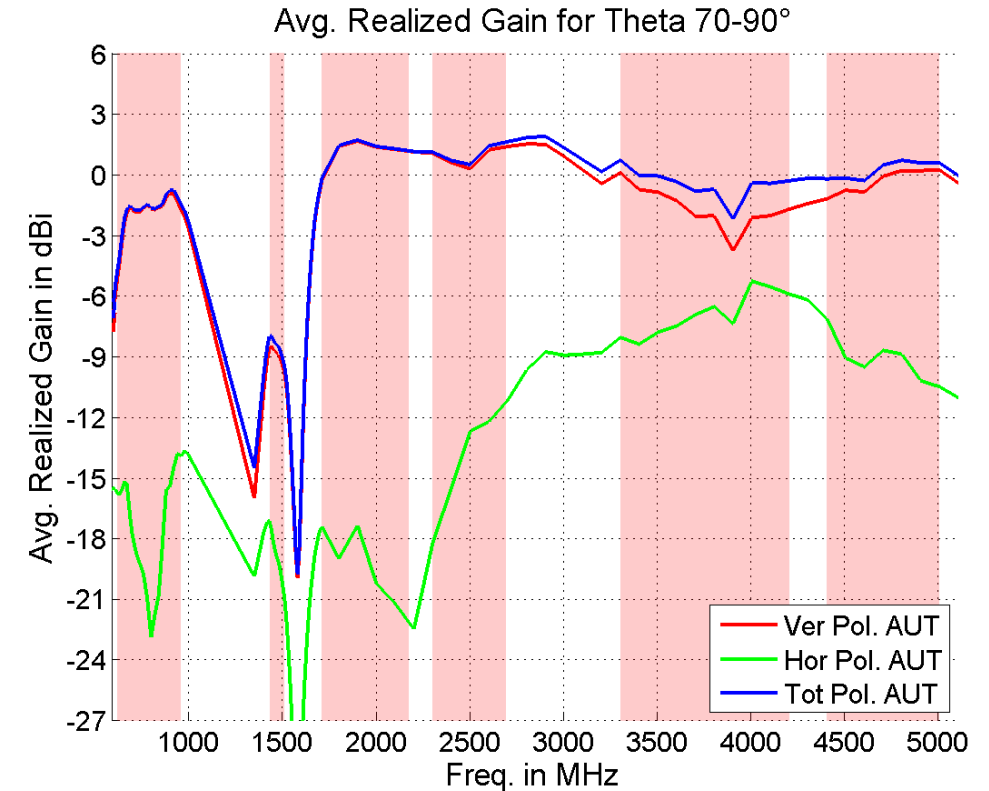
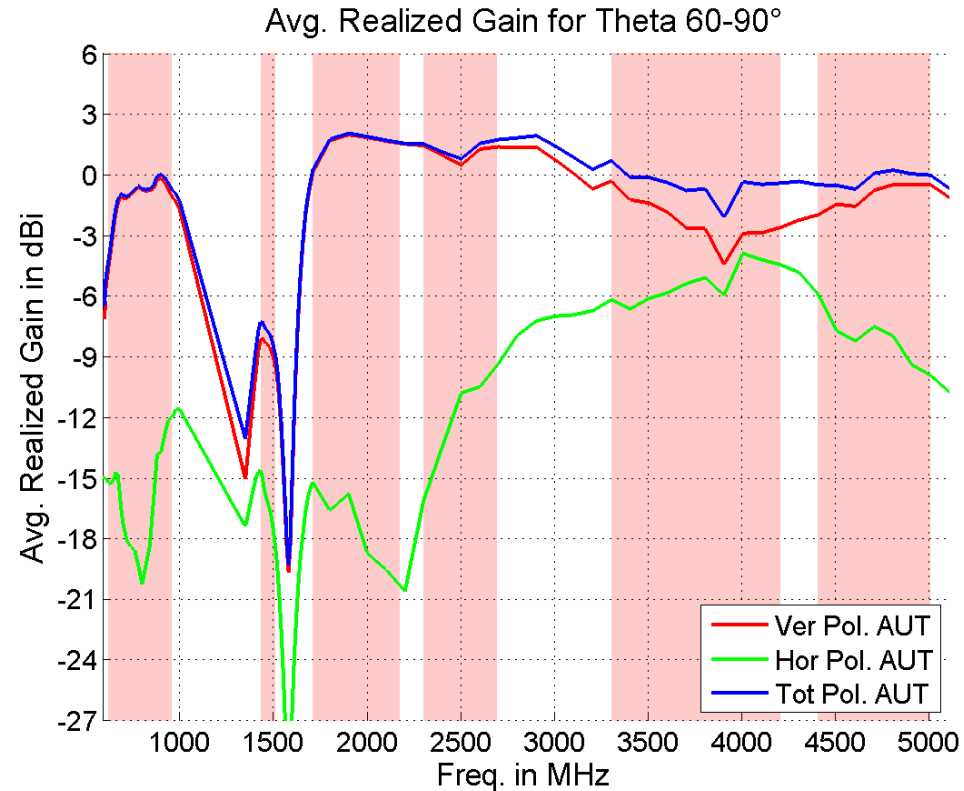
Chamber



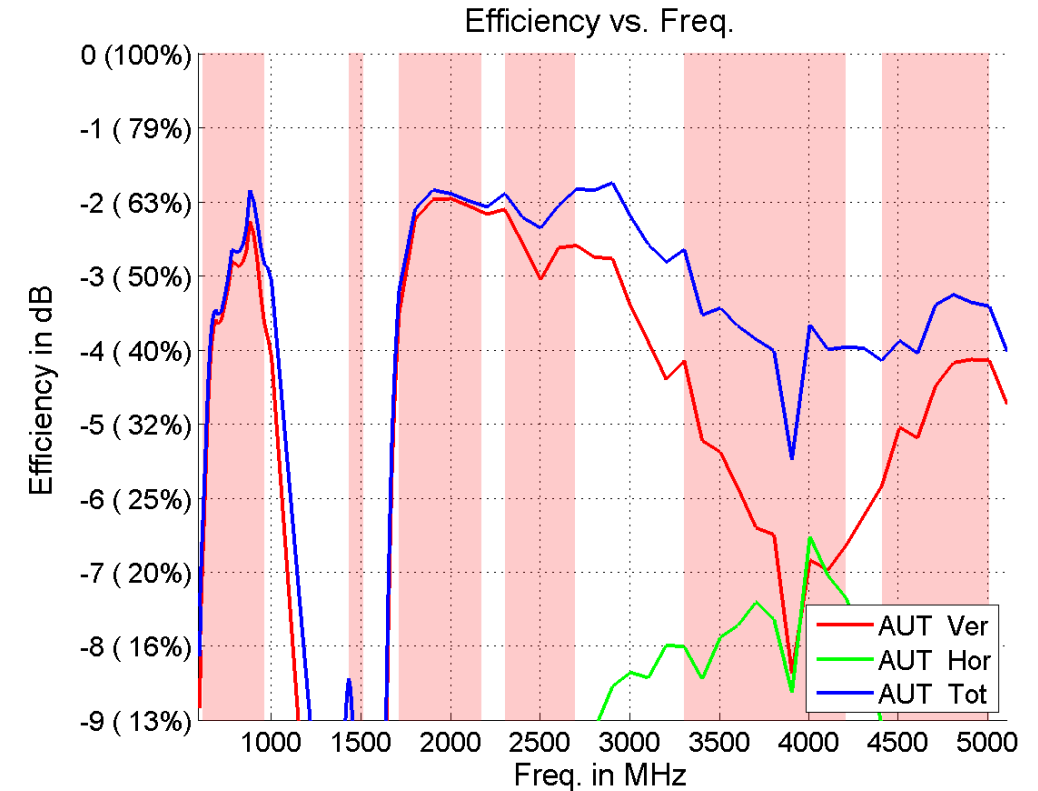
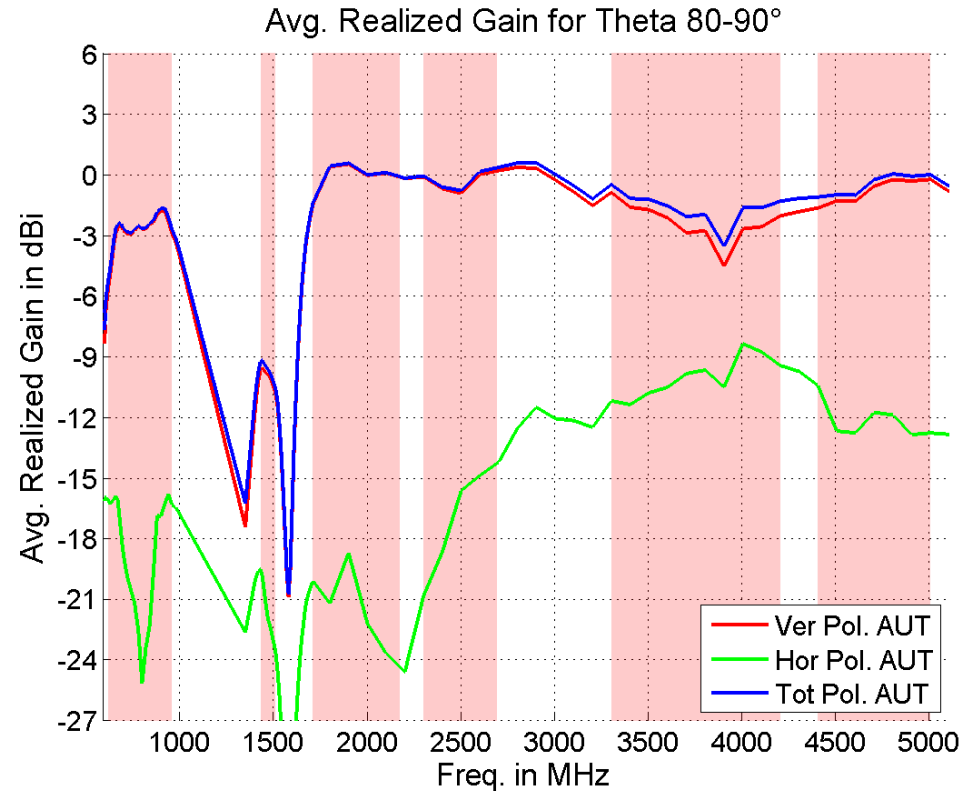
- The MaxGainFF-values are determined with 1.5m RTK031 cable (attenuation added to the measurement results).
- See attached file "Audi_CS_S13b_VariantE02_LTEf_gain_maxFF.csv" for the equivalent raw MaxGainFF-data.



2.1 Variant E: LTE Antenna Performance Gain and Efficiency (LTE front)

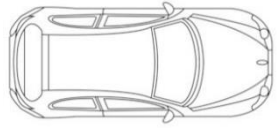


2.1 Variant E: LTE Antenna Performance Gain and Efficiency (LTE front)

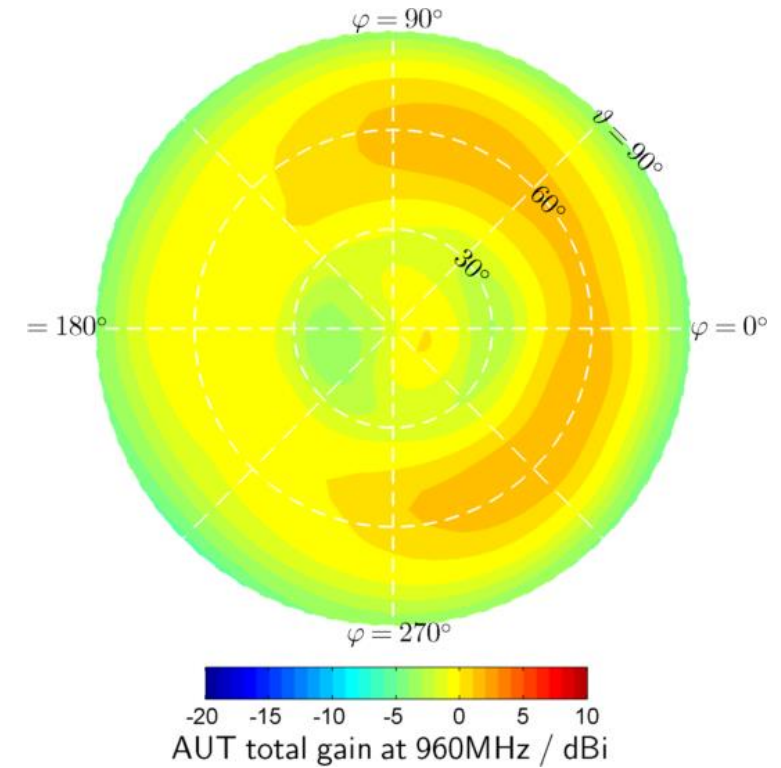
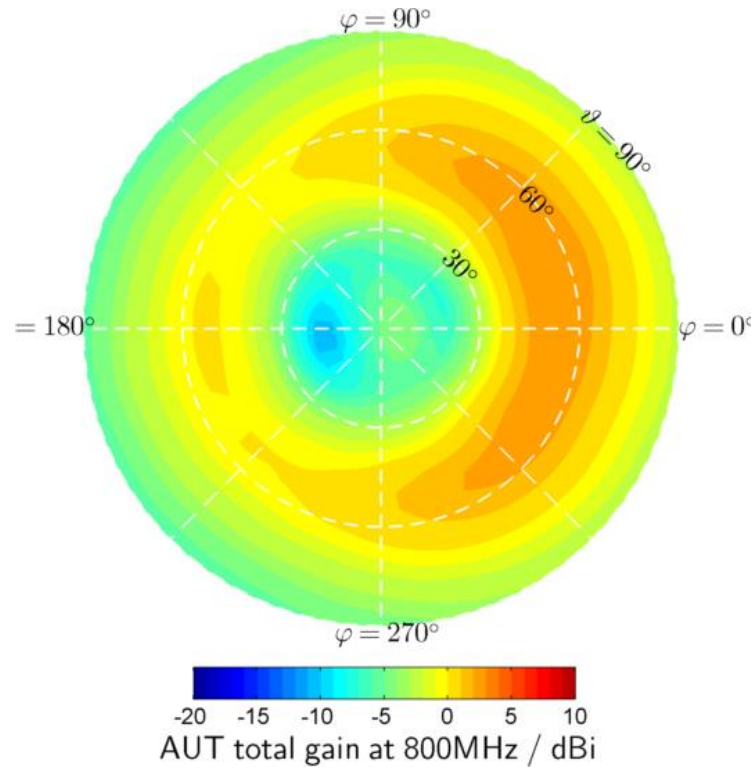
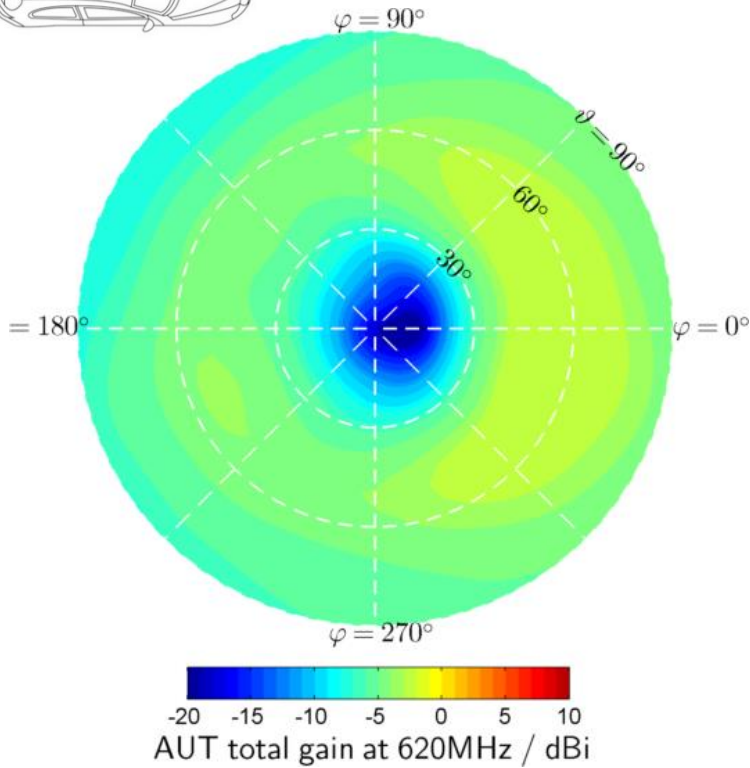


2.1 Variant E: LTE Antenna Performance 3D-Chart (LTE front)

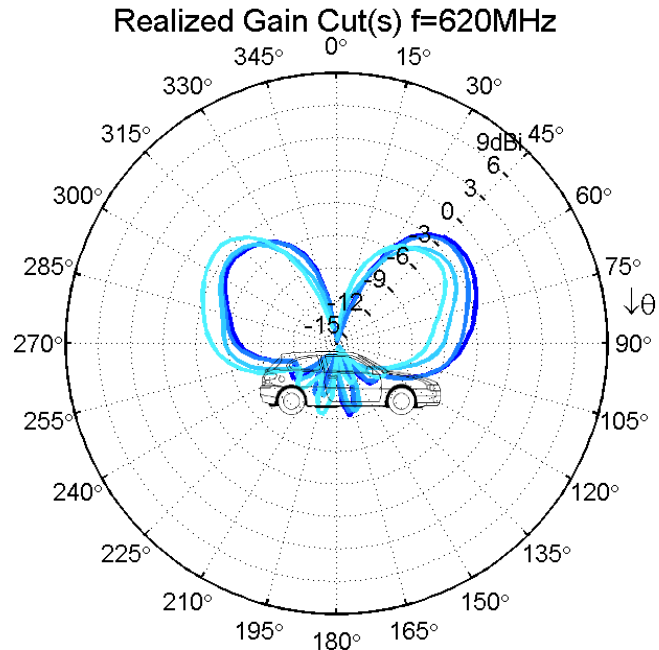
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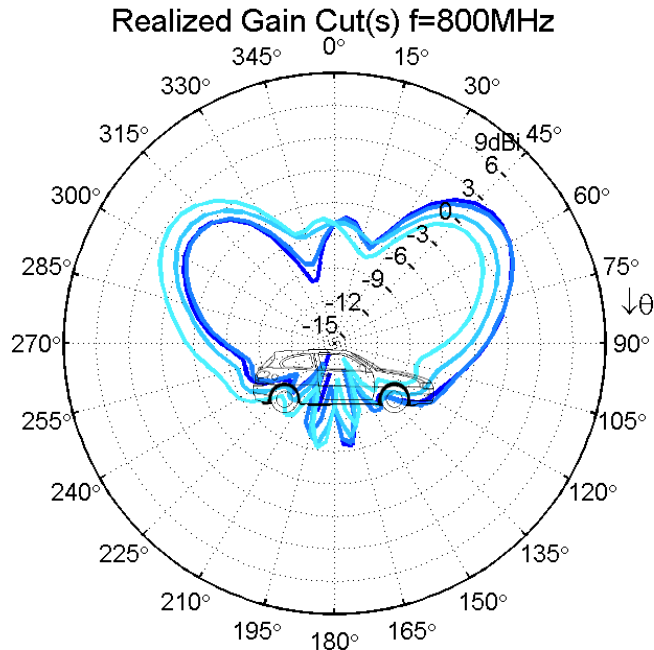
Driving Direction



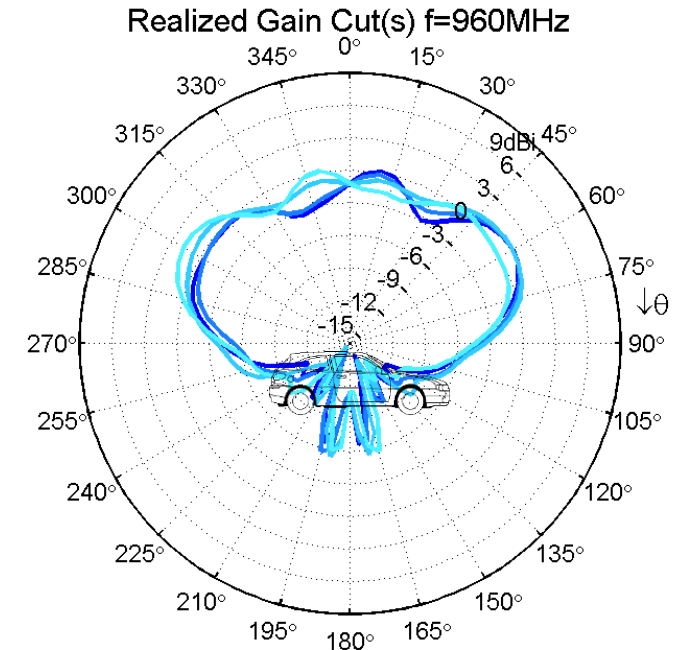
2.1 Variant E: LTE Antenna Performance Gain-Cuts (LTE front)



- AUT , $\phi=0^\circ$, Tot, Avg: -6.8dBi
- AUT , $\phi=45^\circ$, Tot, Avg: -7.0dBi
- AUT , $\phi=90^\circ$, Tot, Avg: -7.5dBi
- AUT , $\phi=135^\circ$, Tot, Avg: -7.2dBi



- AUT , $\phi=0^\circ$, Tot, Avg: -3.3dBi
- AUT , $\phi=45^\circ$, Tot, Avg: -3.4dBi
- AUT , $\phi=90^\circ$, Tot, Avg: -3.6dBi
- AUT , $\phi=135^\circ$, Tot, Avg: -3.5dBi

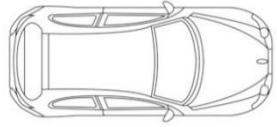


- AUT , $\phi=0^\circ$, Tot, Avg: -3.3dBi
- AUT , $\phi=45^\circ$, Tot, Avg: -3.2dBi
- AUT , $\phi=90^\circ$, Tot, Avg: -2.7dBi
- AUT , $\phi=135^\circ$, Tot, Avg: -2.9dBi

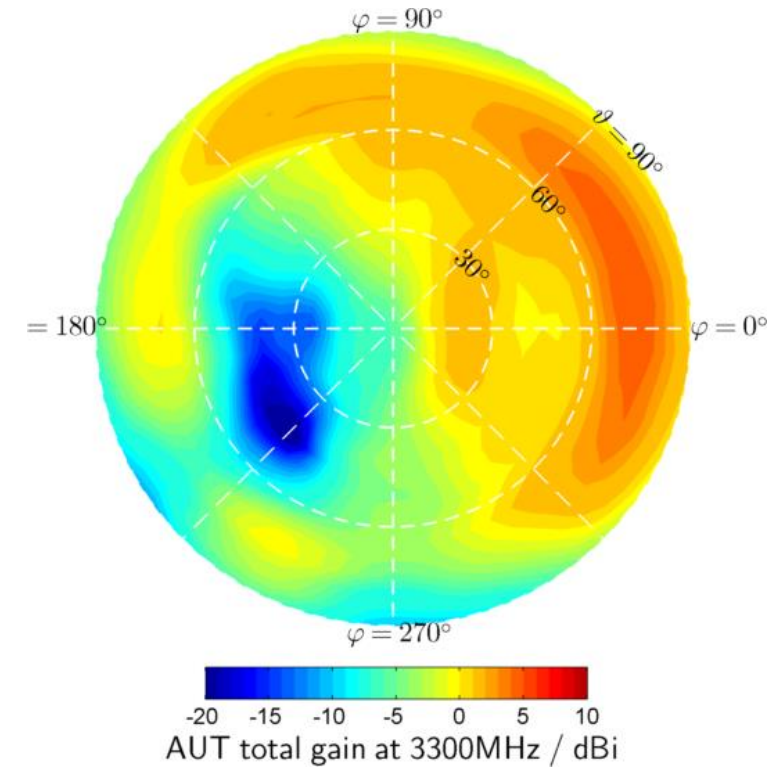
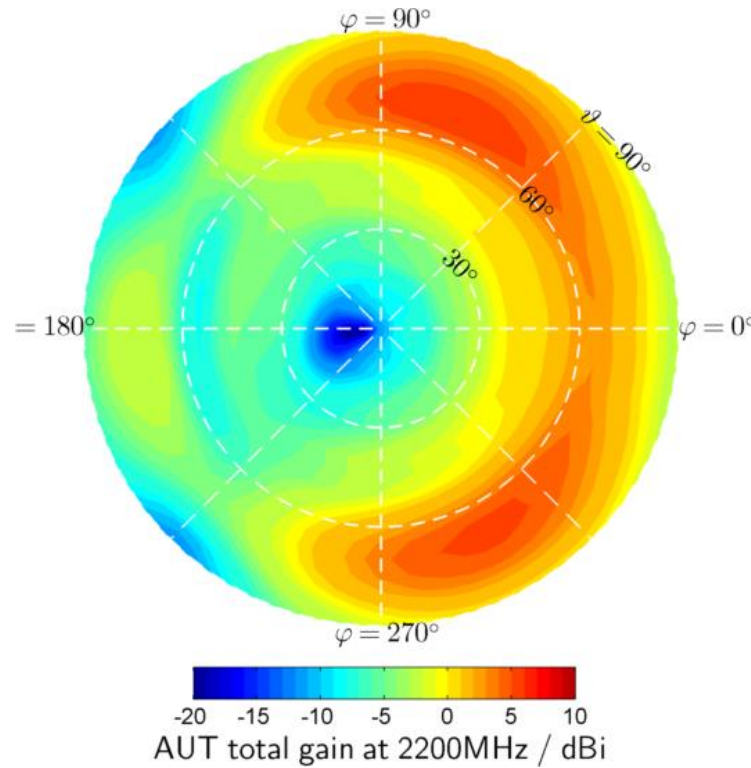
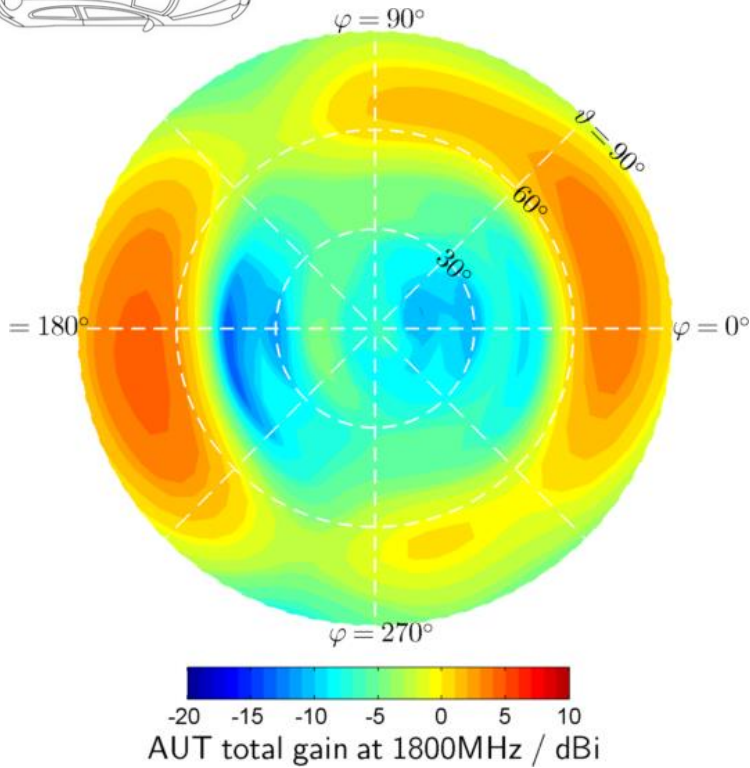


2.1 Variant E: LTE Antenna Performance 3D-Chart (LTE front)

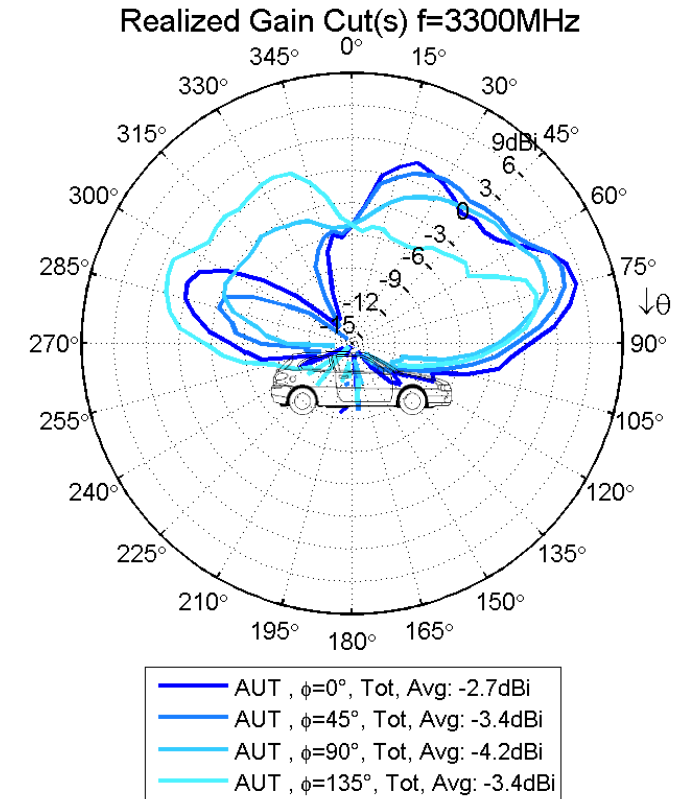
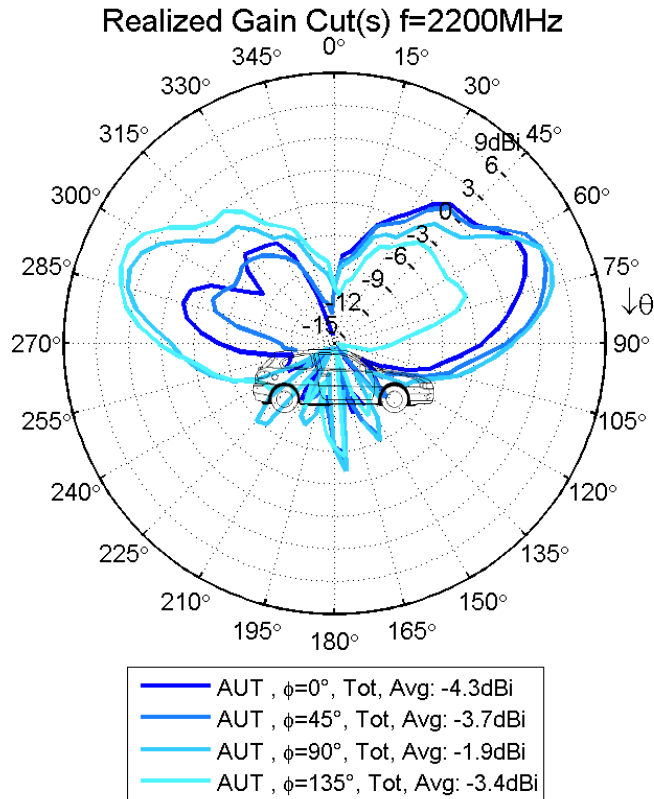
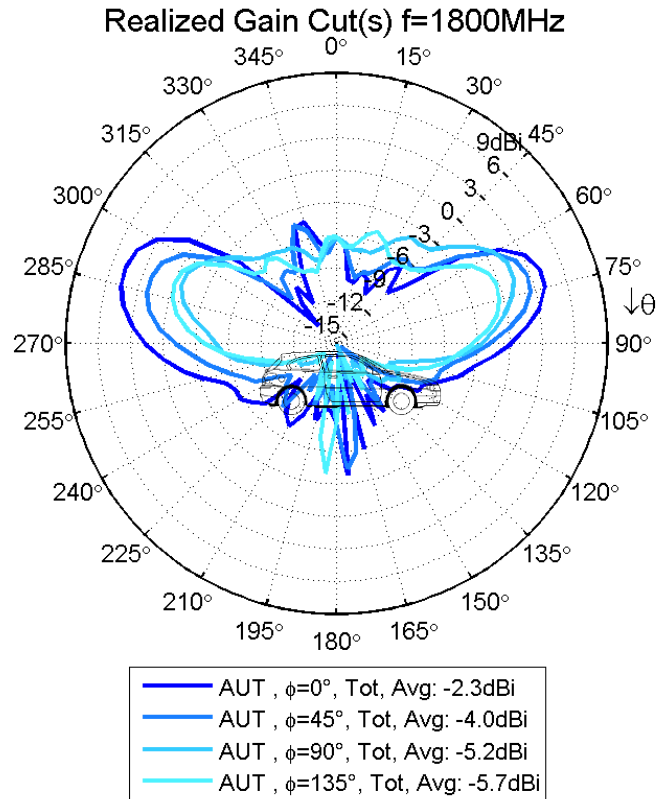
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Driving Direction

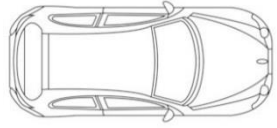


2.1 Variant E: LTE Antenna Performance Gain-Cuts (LTE front)

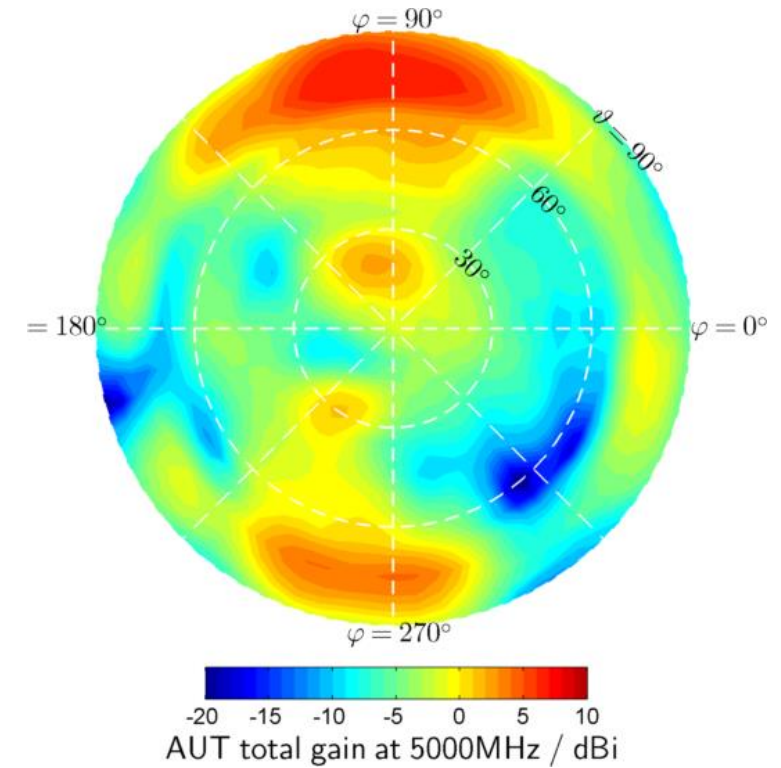
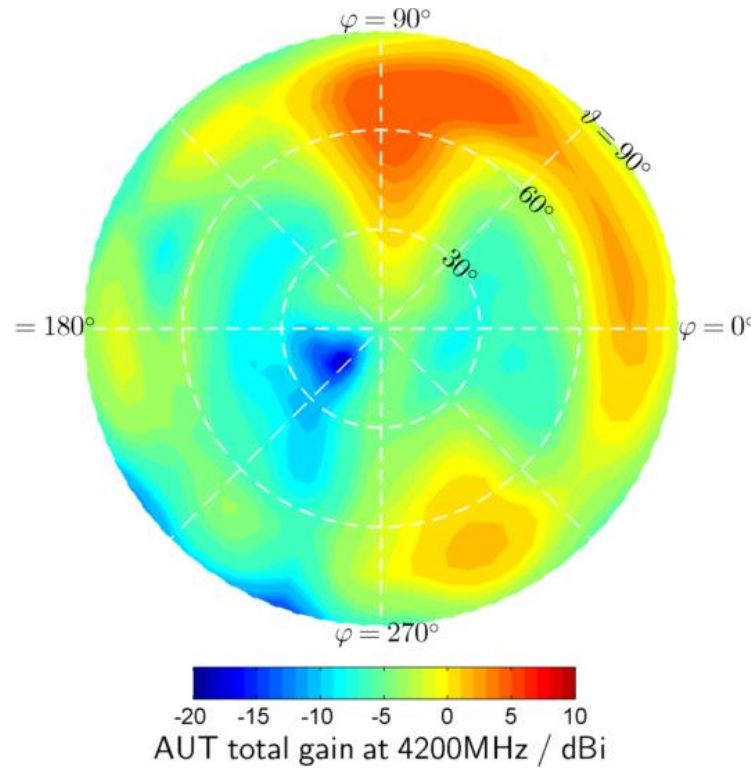
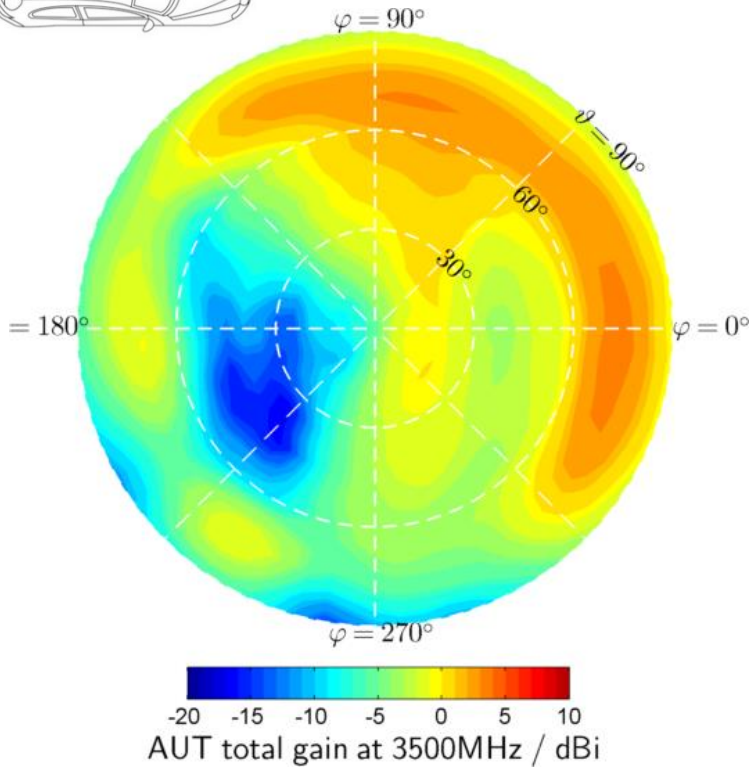


2.1 Variant E: LTE Antenna Performance 3D-Chart (LTE front)

Chamber

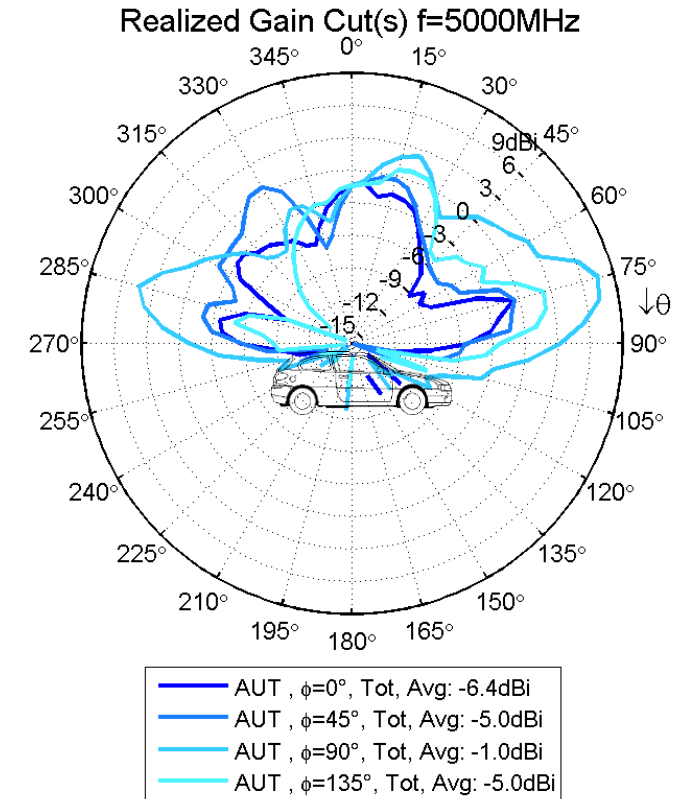
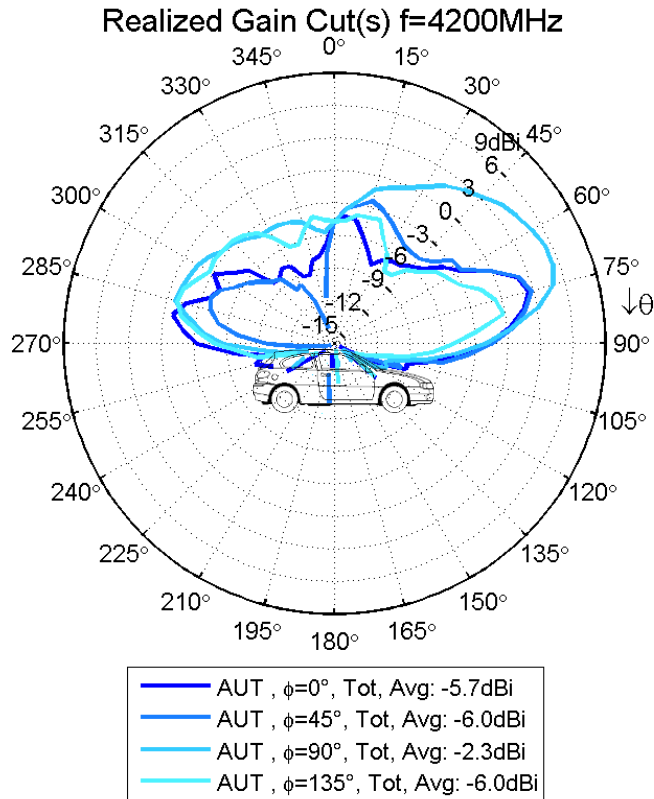
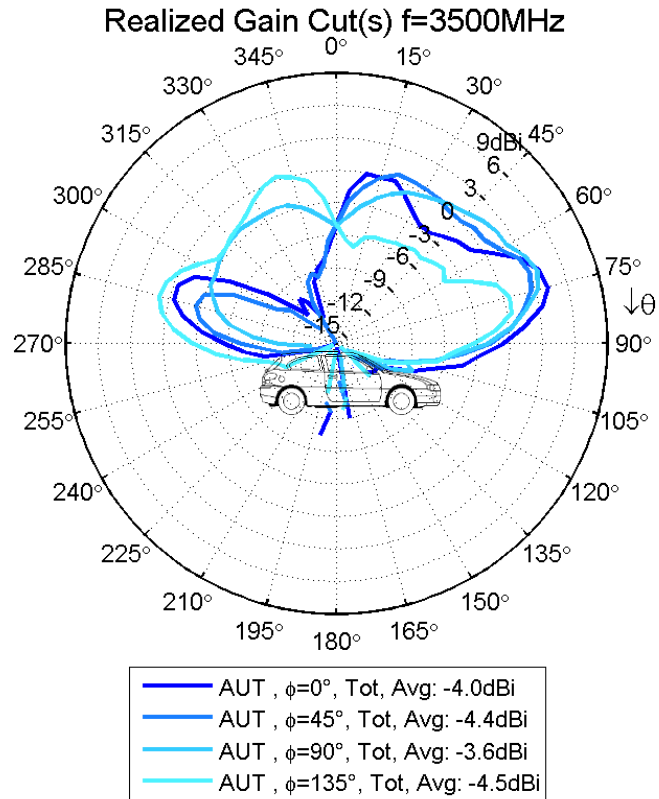


Driving Direction



2.1 Variant E: LTE Antenna Performance Gain-Cuts (LTE front)

Chamber

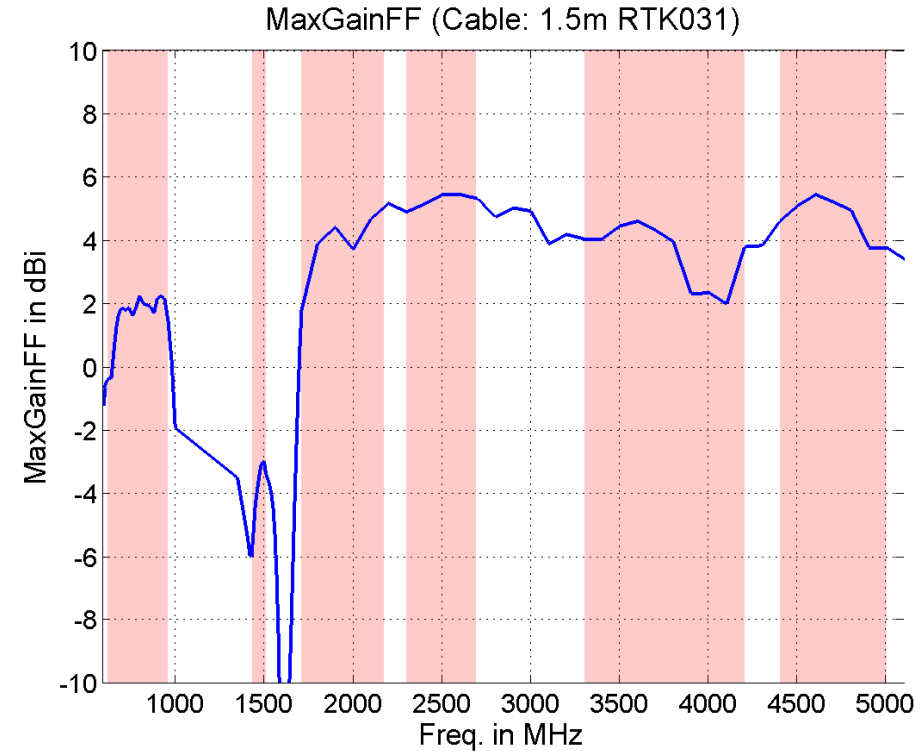
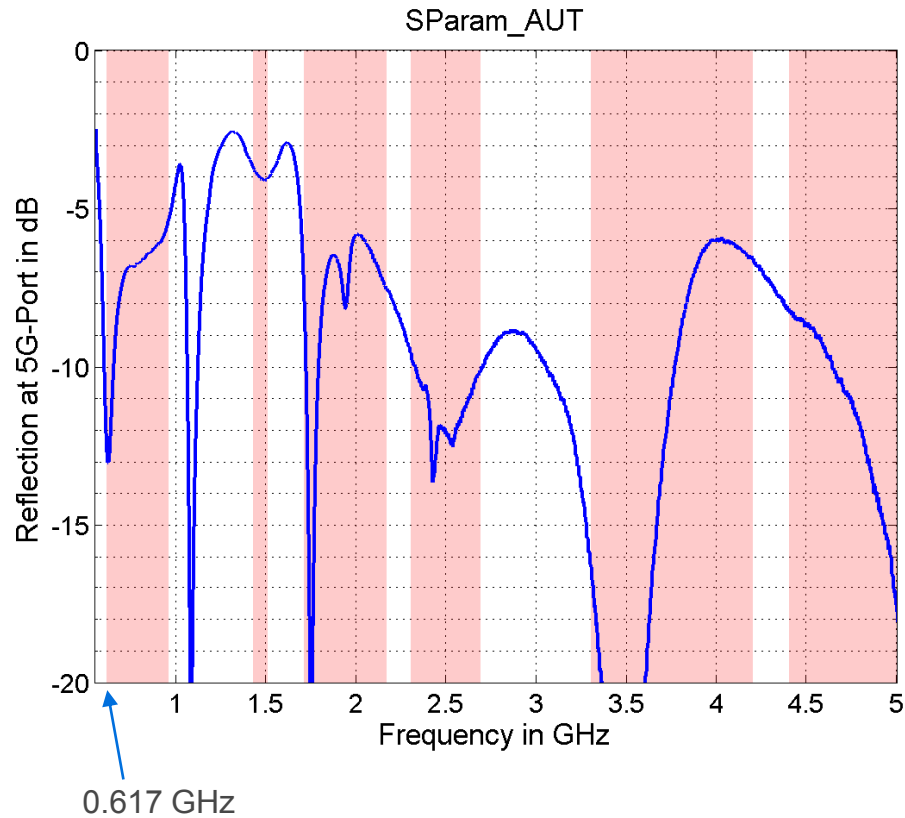


2.2 LTE Back (LTEb)



2.2 Variant E: LTE Antenna Performance Matching (LTE back)

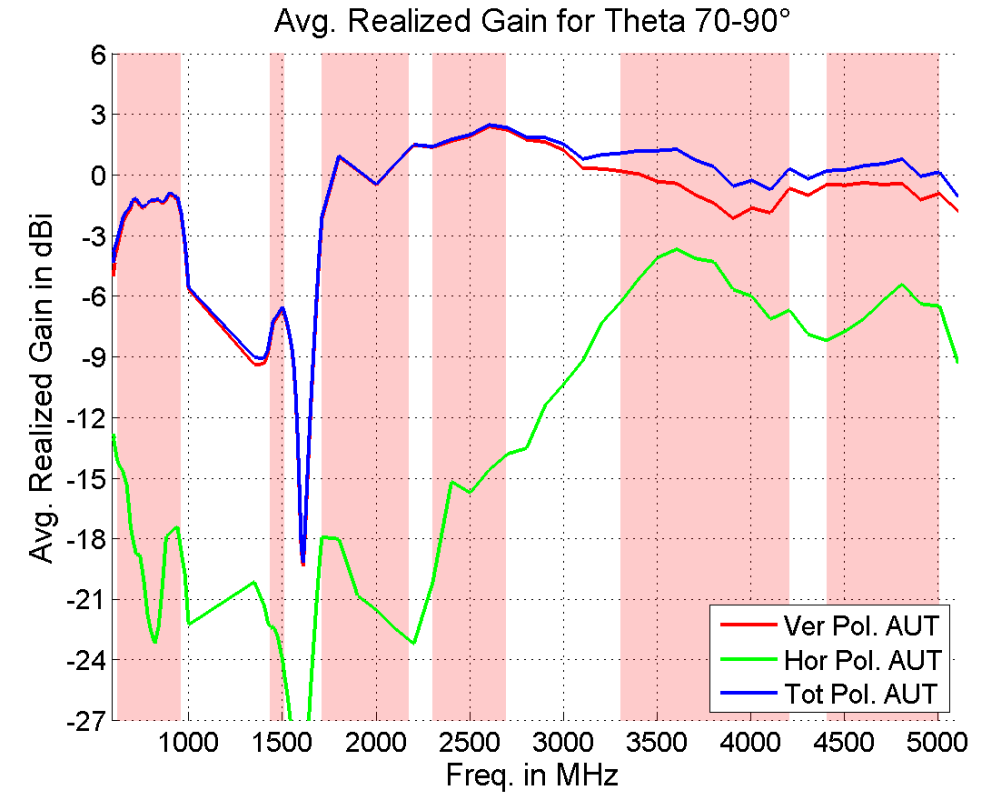
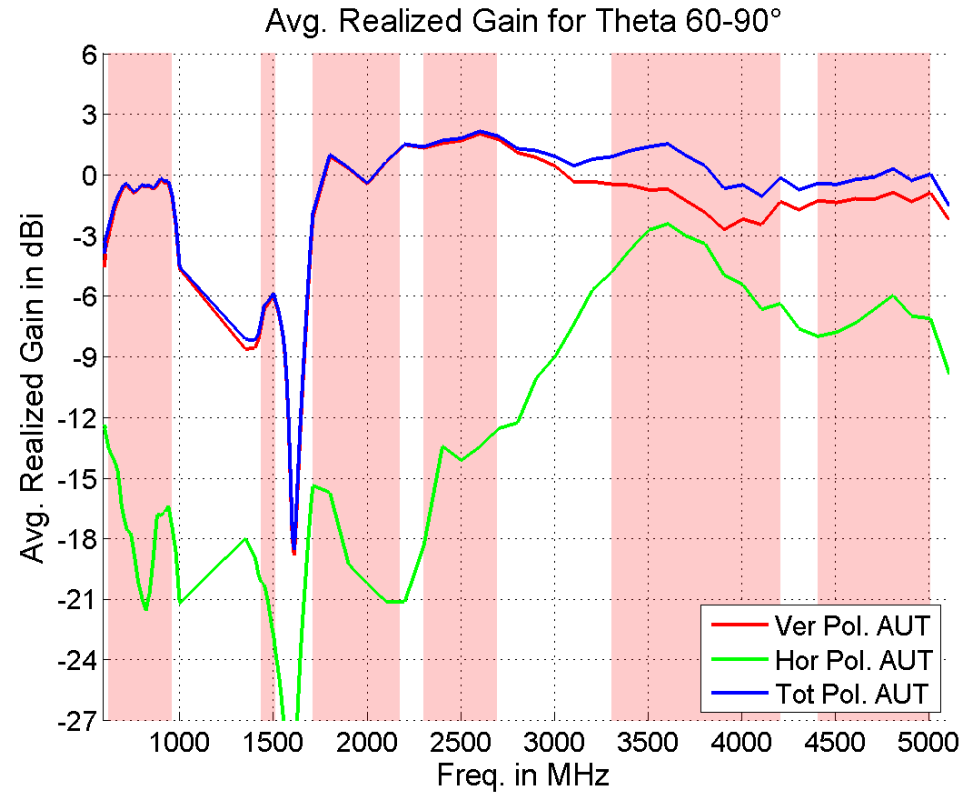
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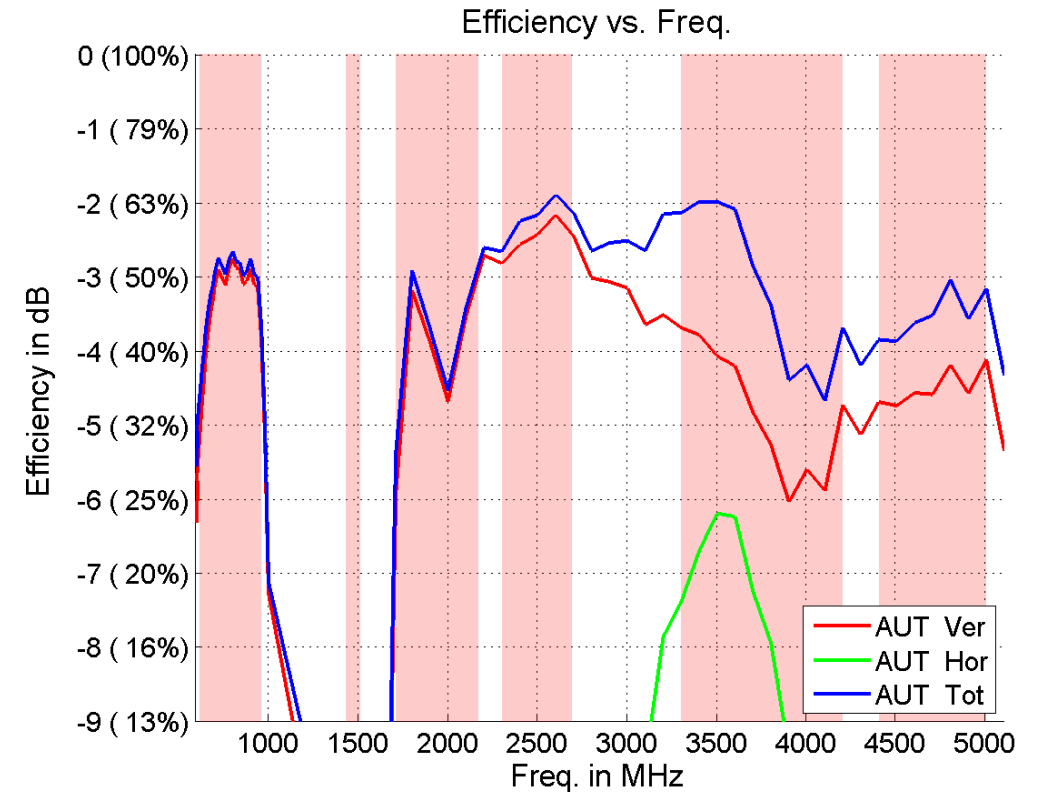
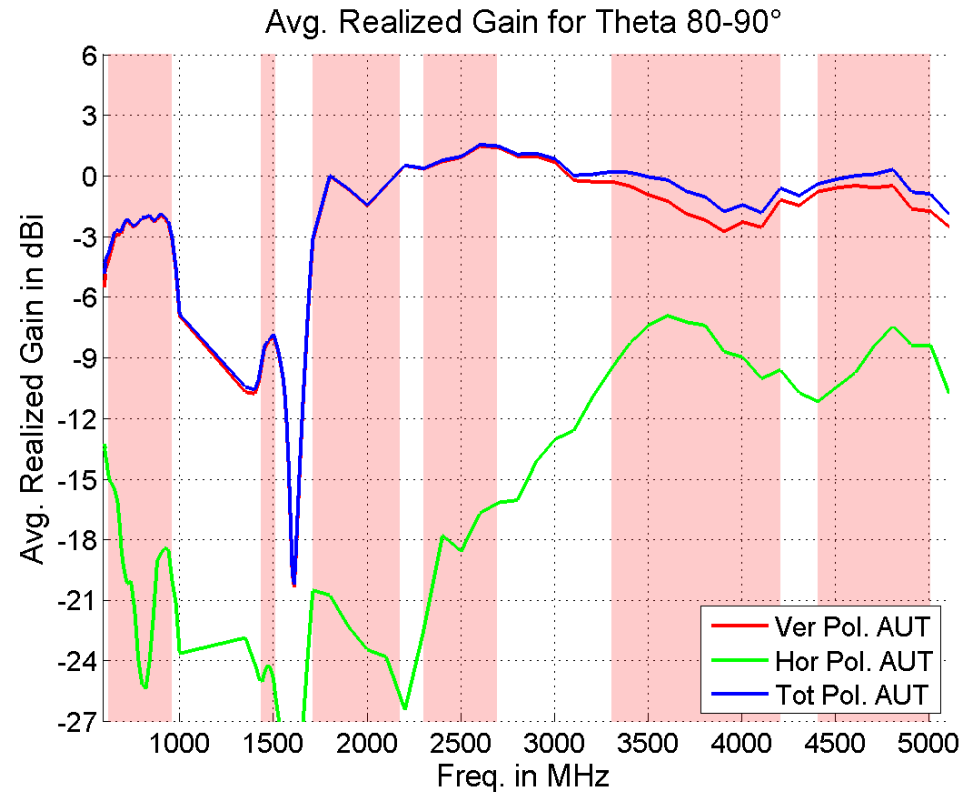
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- See attached file “Audi_CS_S13b_VariantE02_LTEb_gain_maxFF.csv” for the equivalent raw MaxGainFF-data.



2.2 Variant E: LTE Antenna Performance Gain and Efficiency (LTE back)

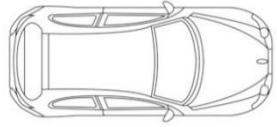


2.2 Variant E: LTE Antenna Performance Gain and Efficiency (LTE back)

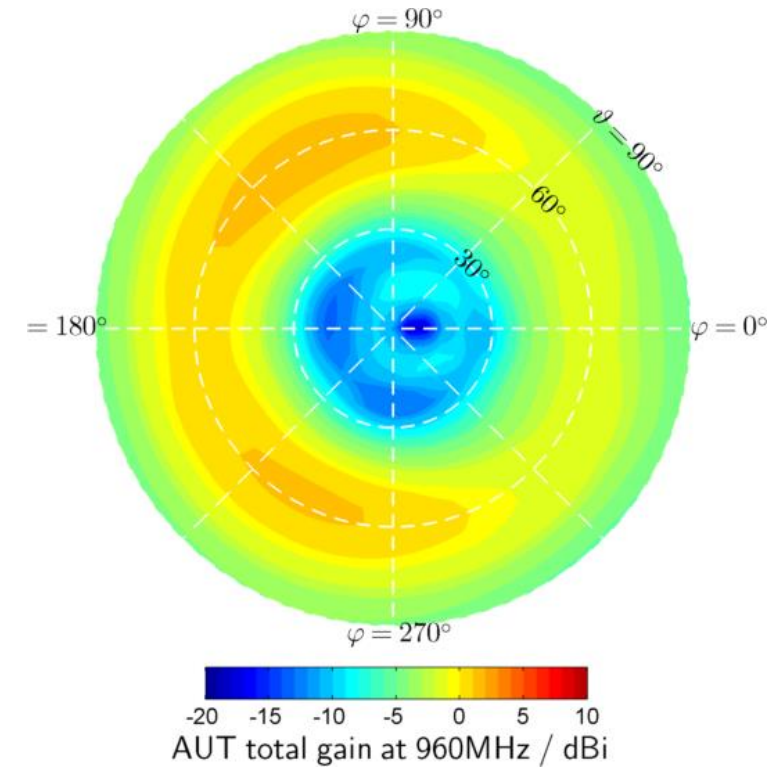
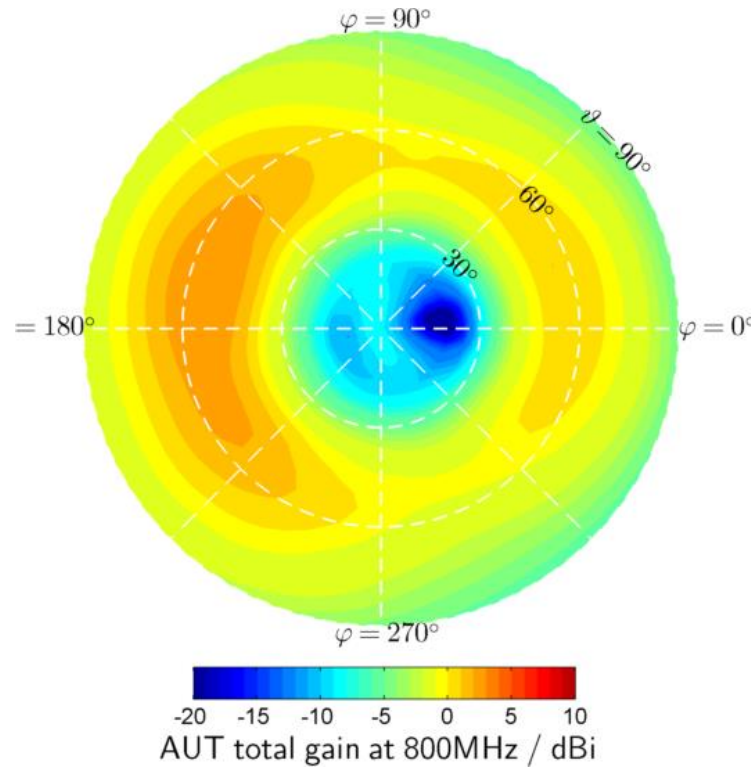
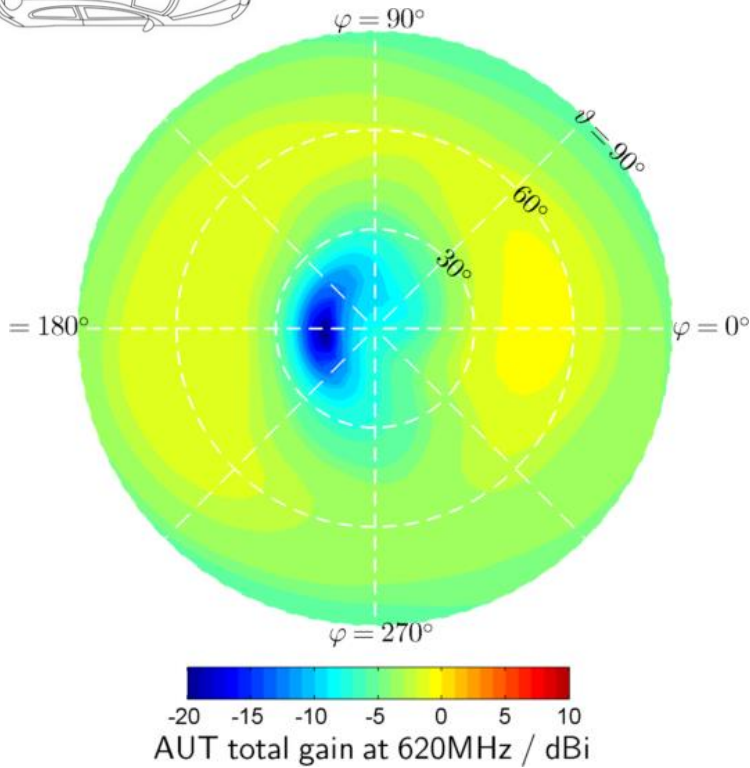


2.2 Variant E: LTE Antenna Performance 3D-Chart (LTE back)

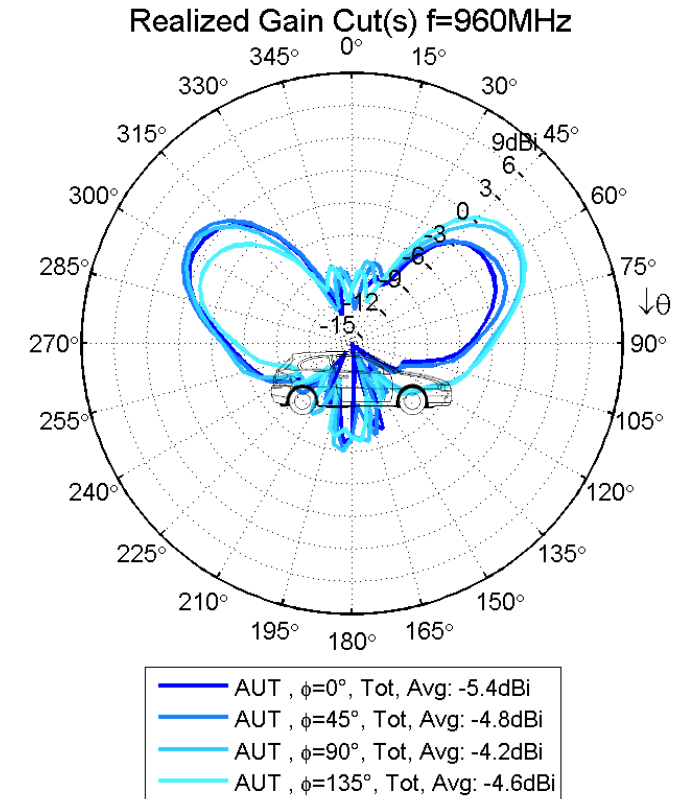
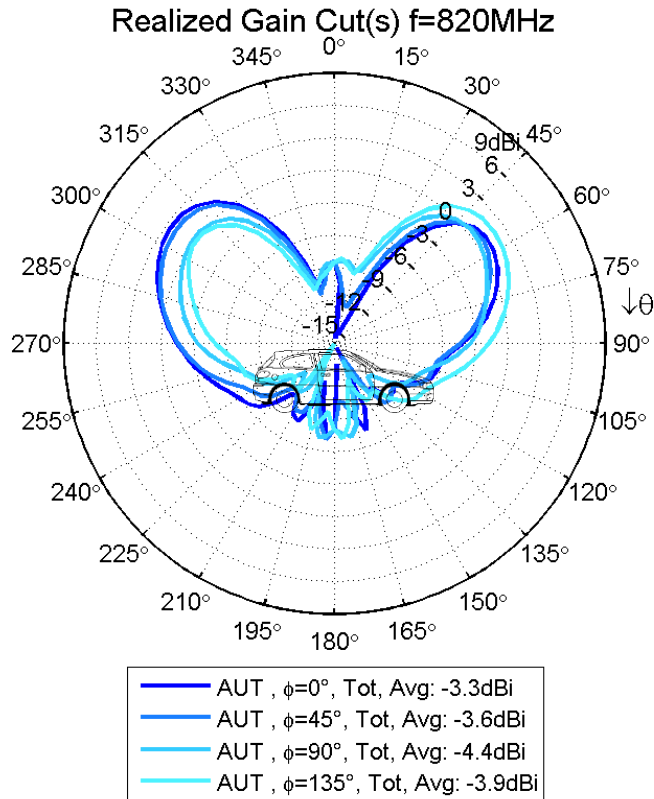
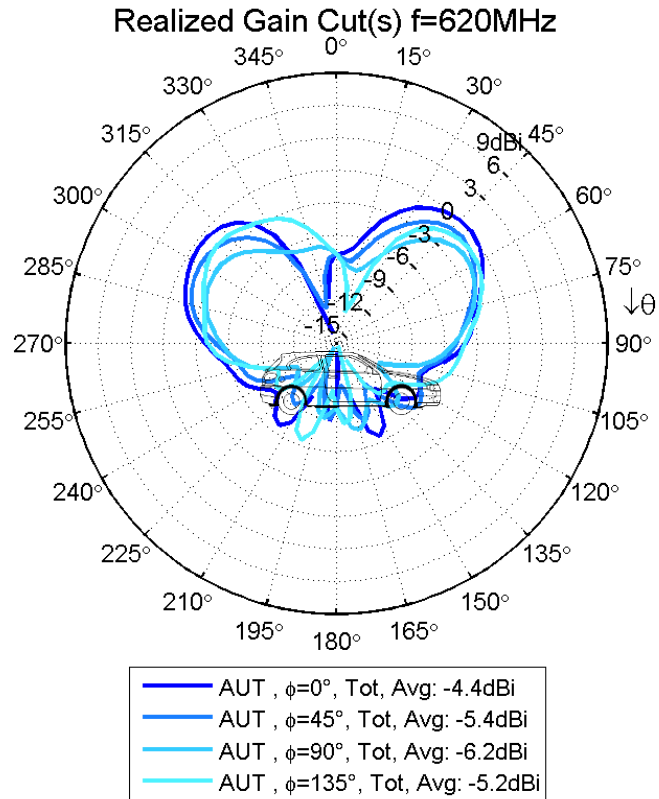
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Driving Direction

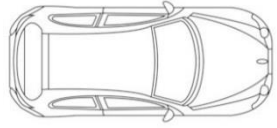


2.2 Variant E: LTE Antenna Performance Gain-Cuts (LTE back)

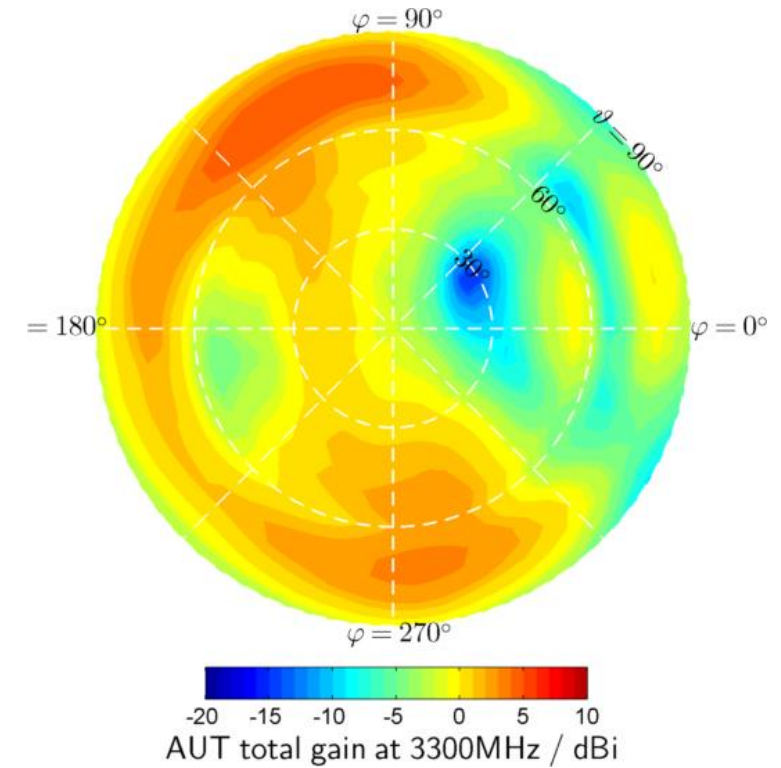
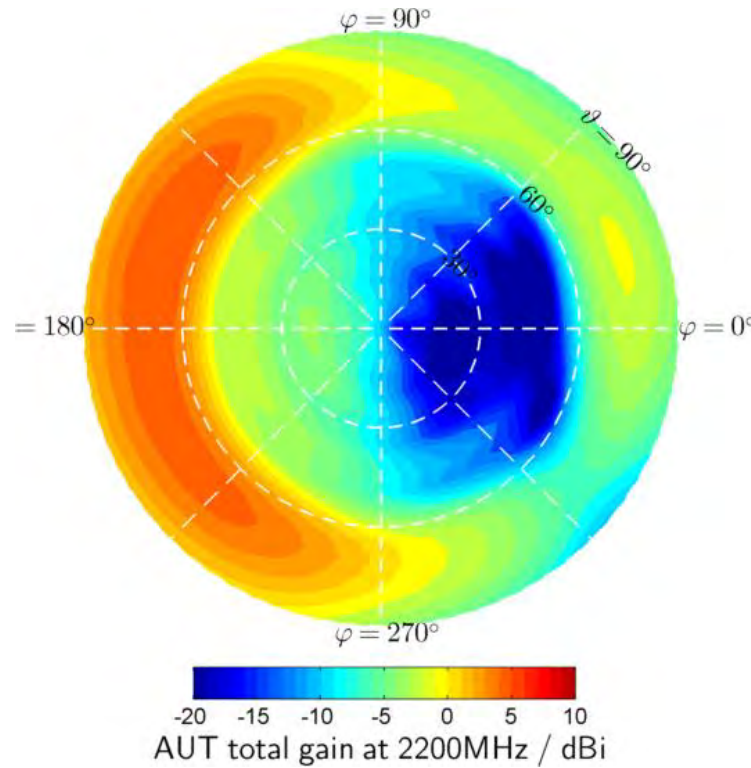
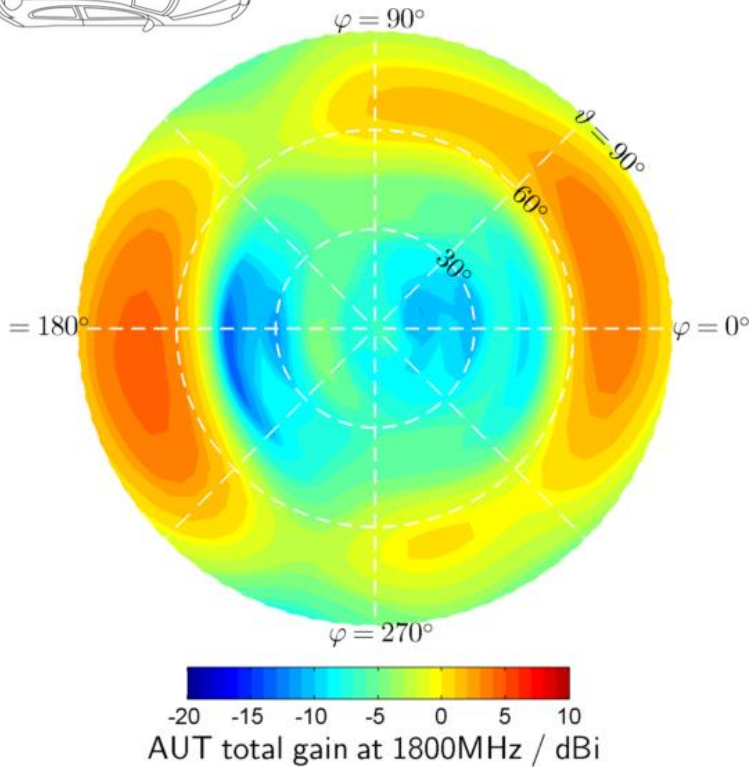


2.2 Variant E: LTE Antenna Performance 3D-Chart (LTE back)

Chamber

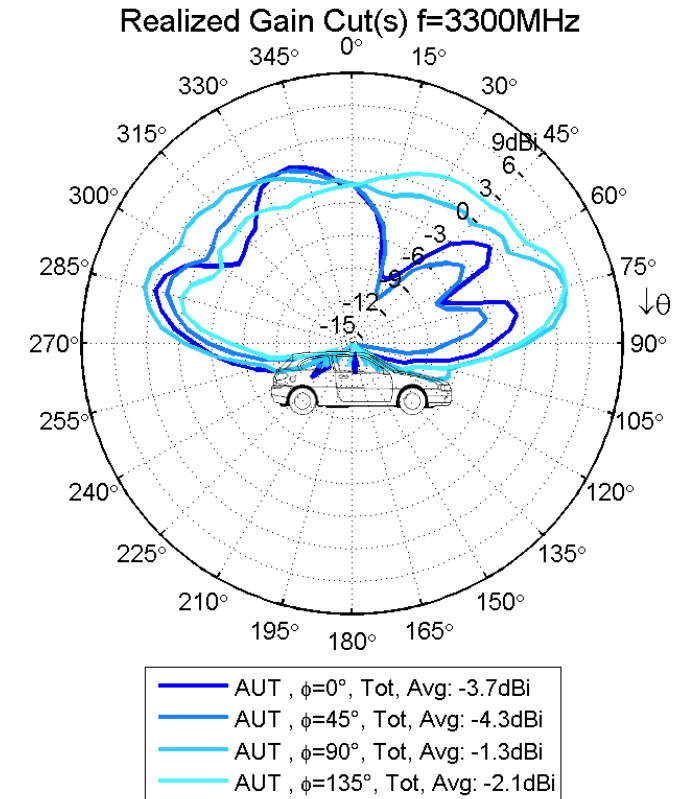
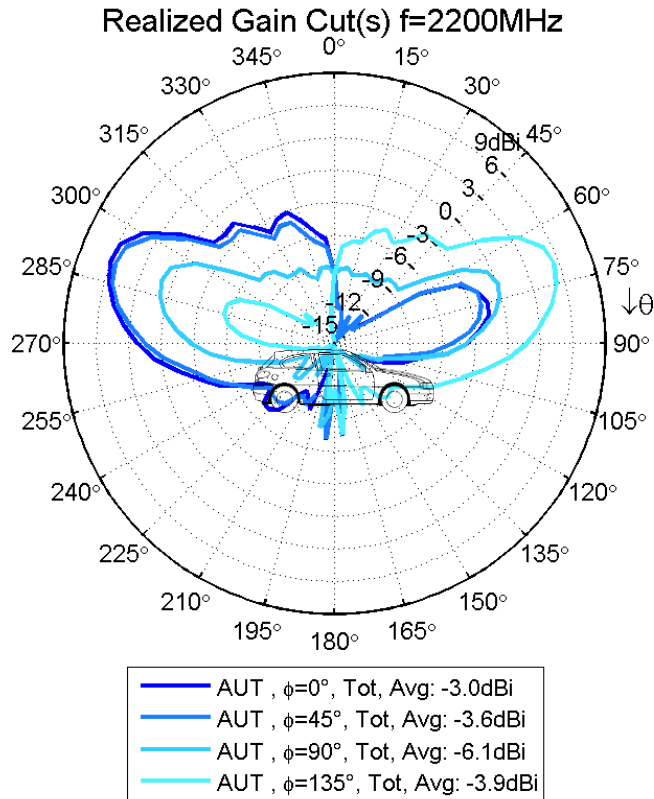
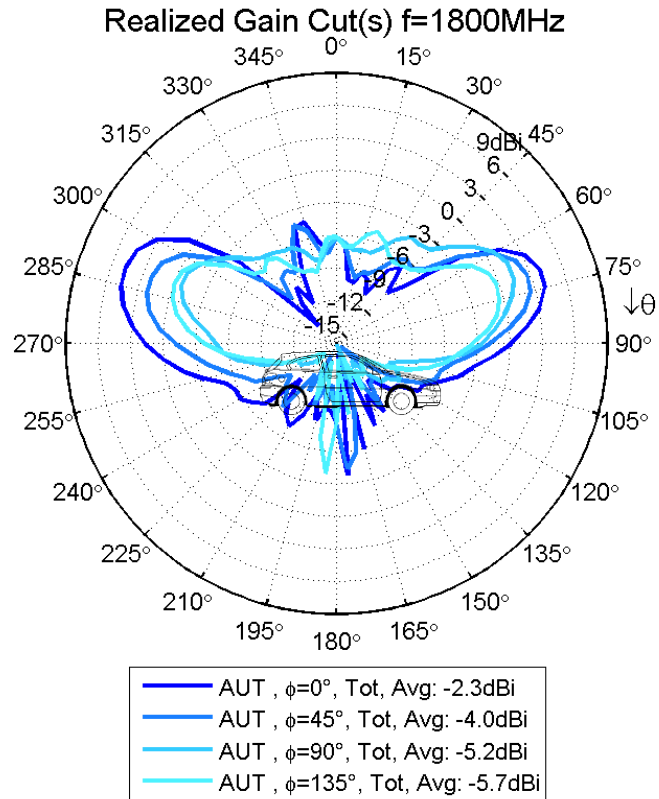


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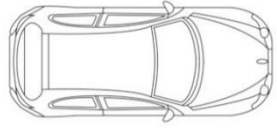
2.2 Variant E: LTE Antenna Performance Gain-Cuts (LTE back)

Chamber

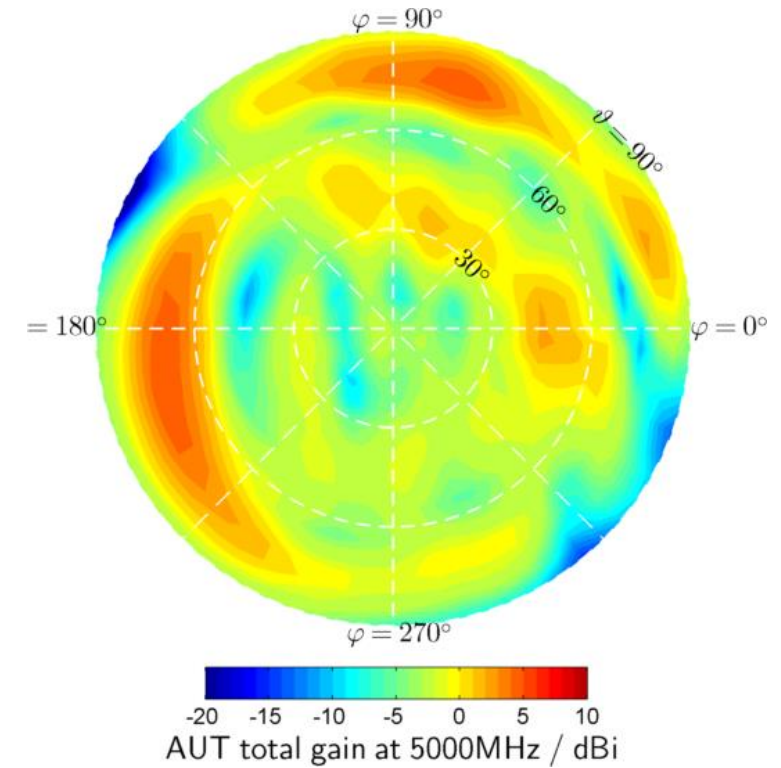
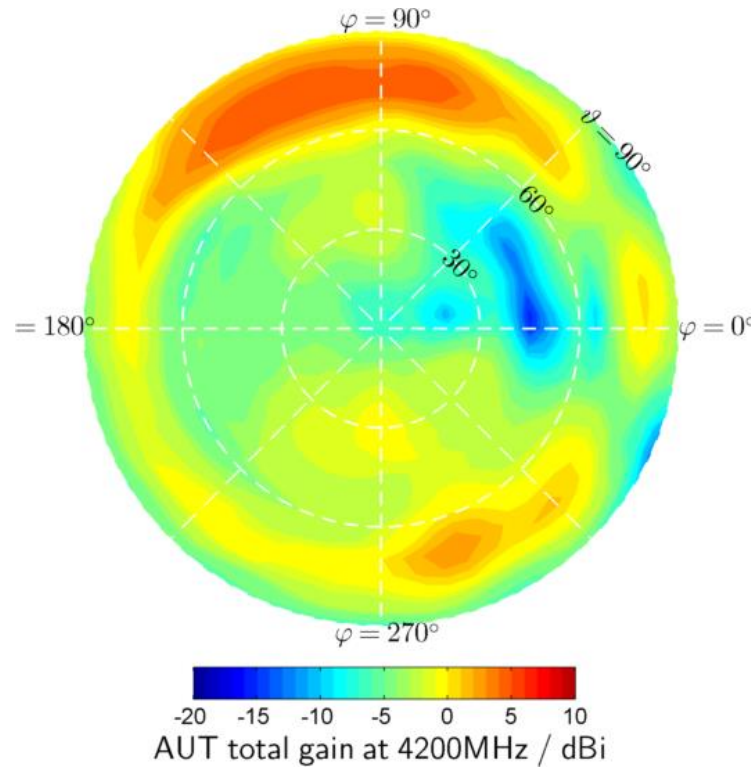
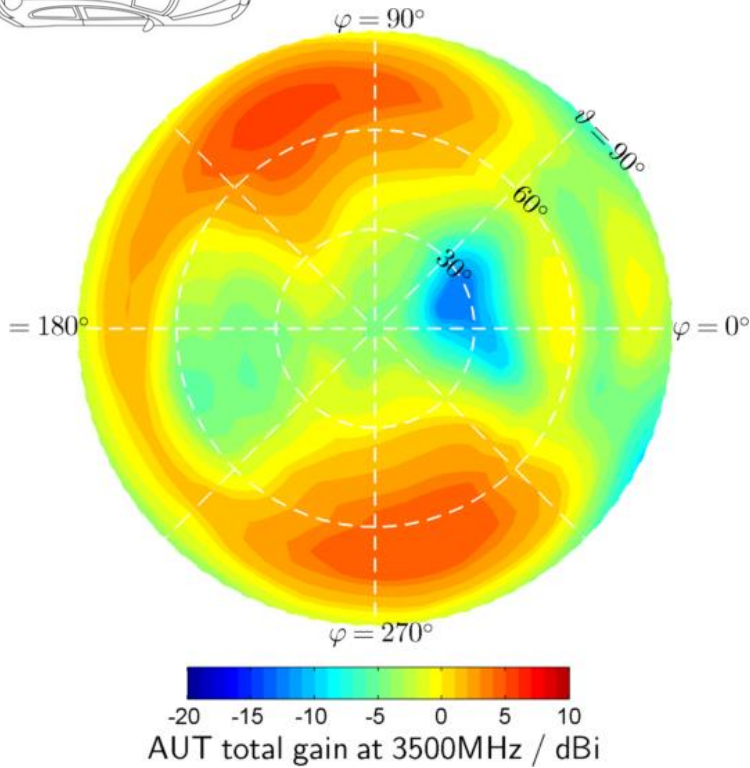


2.2 Variant E: LTE Antenna Performance 3D-Chart (LTE back)

Chamber

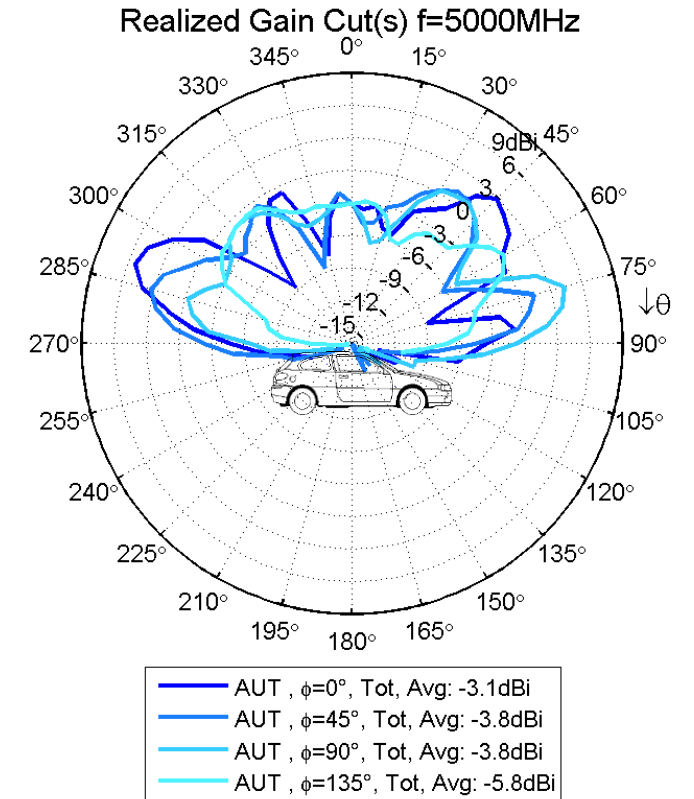
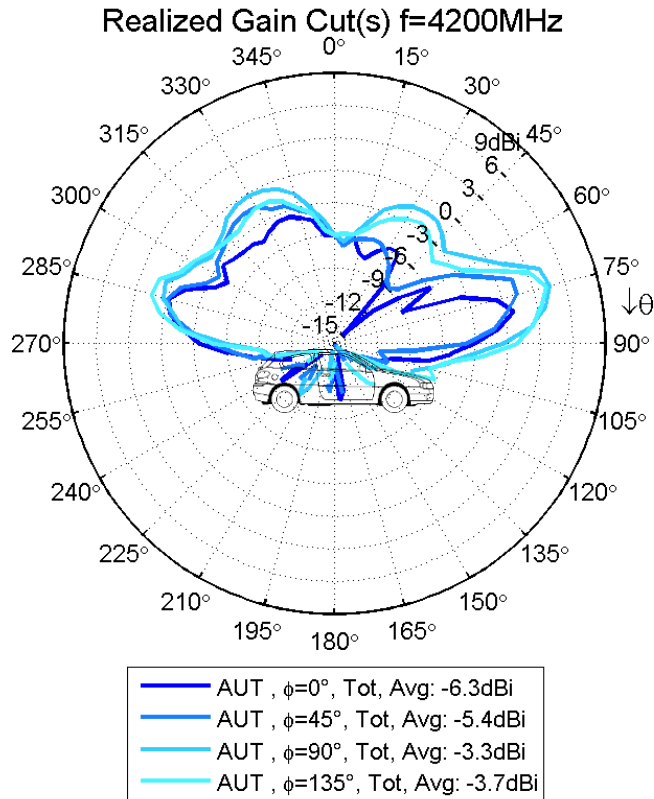
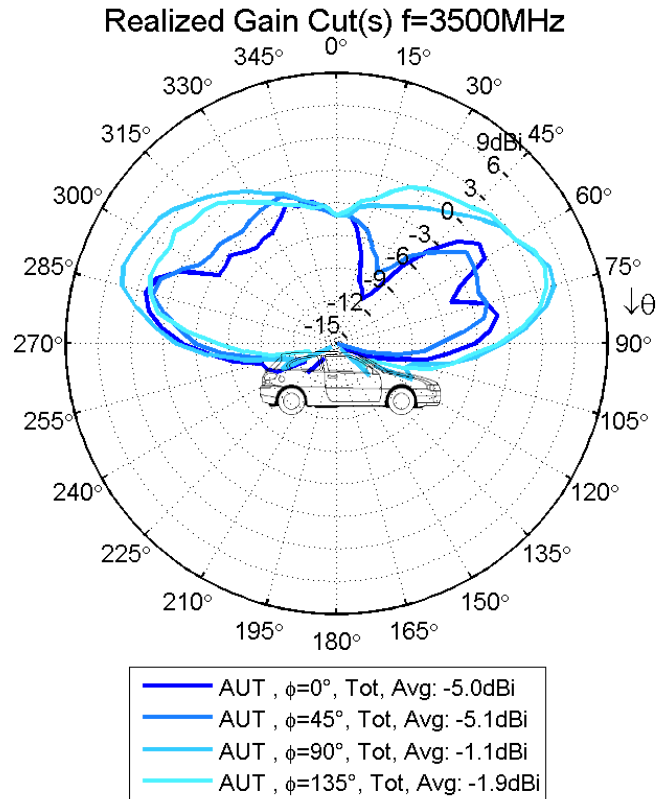


Driving Direction



2.2 Variant E: LTE Antenna Performance Gain-Cuts (LTE back)

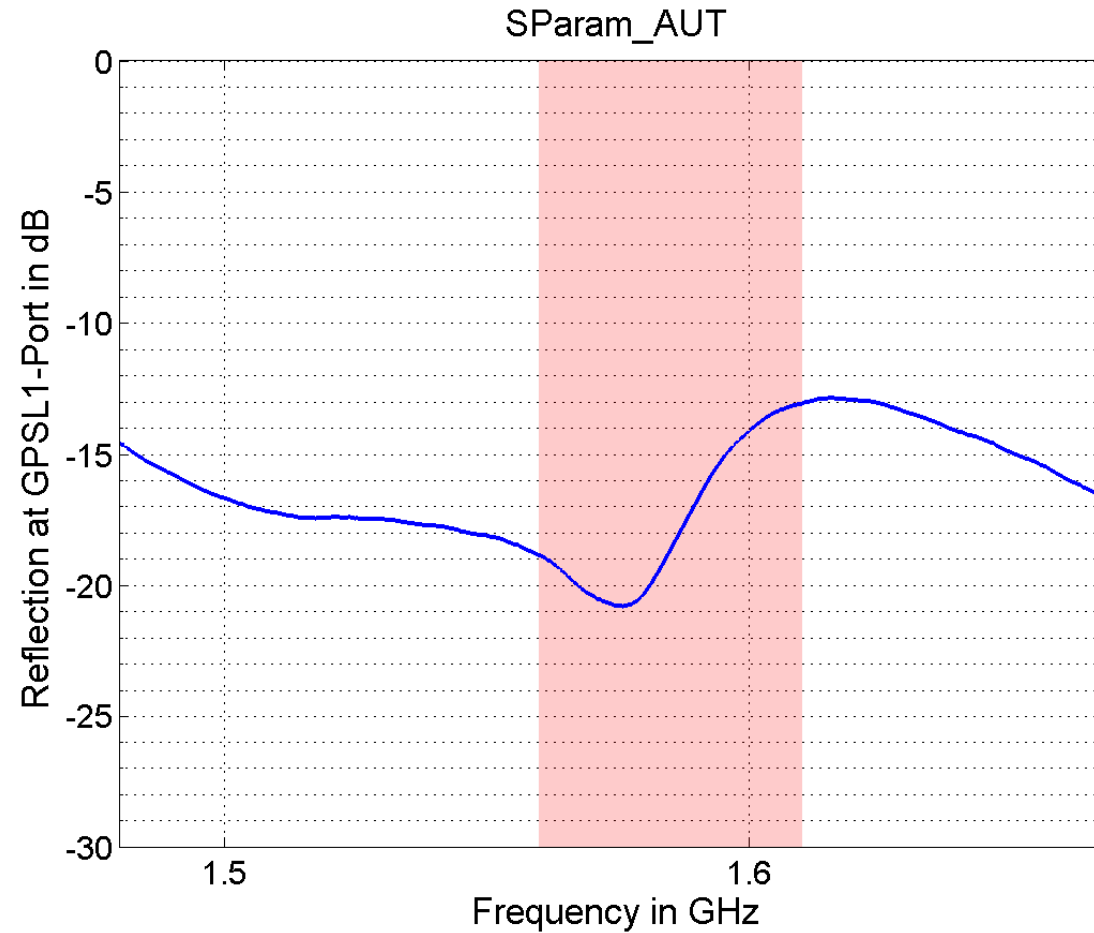
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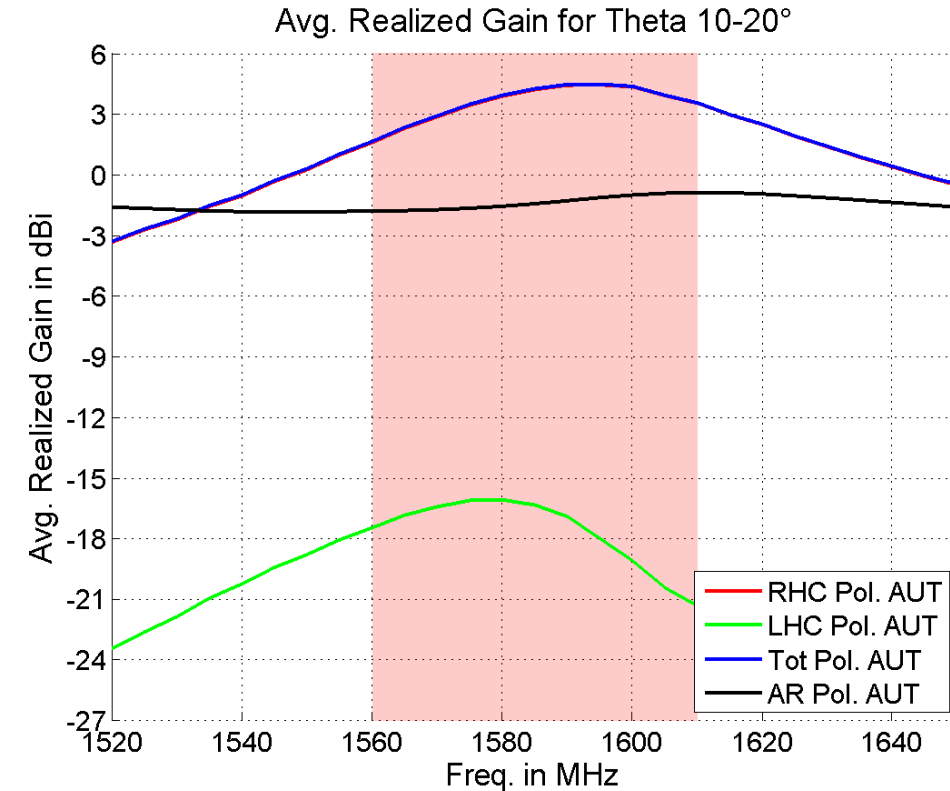
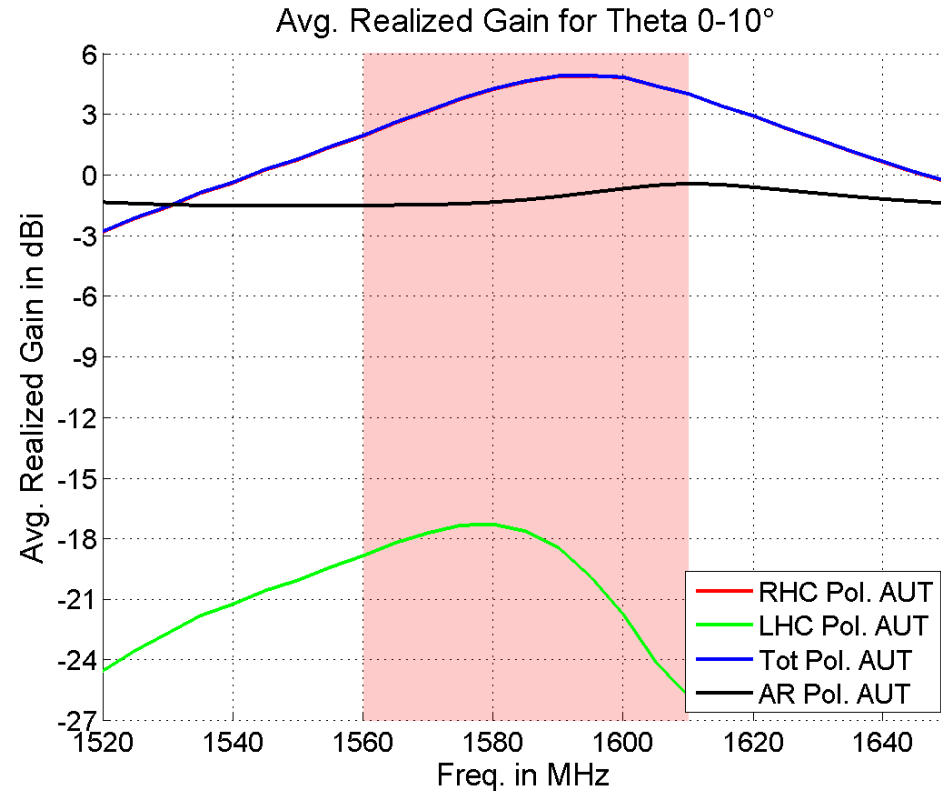
2.3 GNSS L1



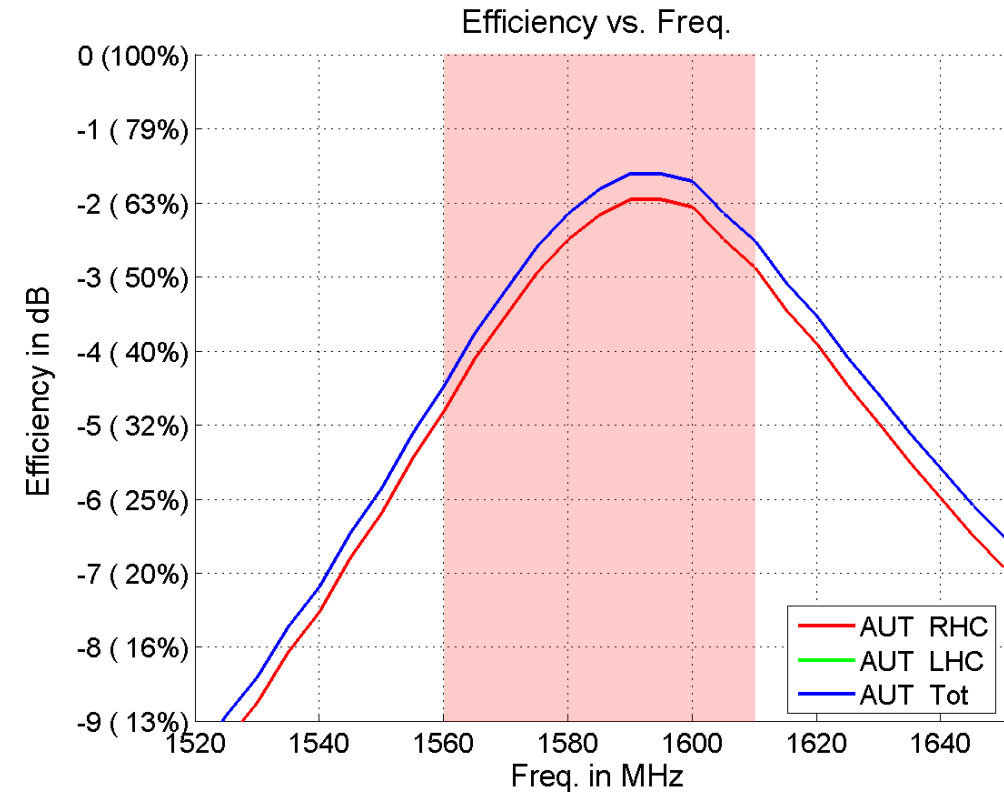
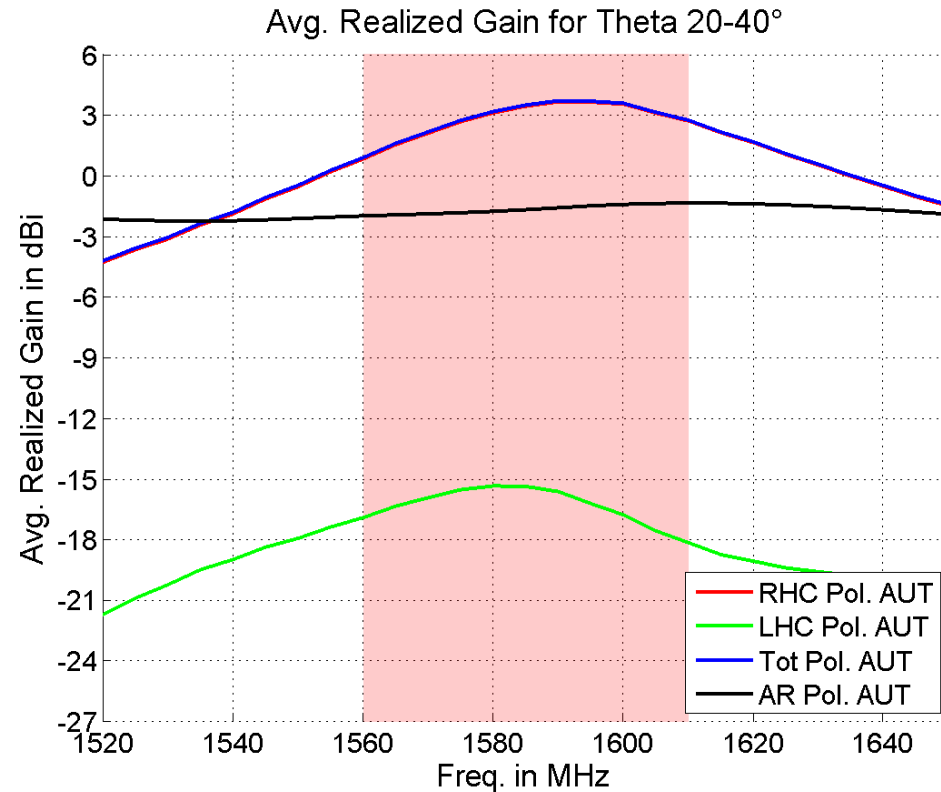
2.3 Variant E: Satellite Antenna Performance Matching (GNSS L1)



2.3 Variant E: Satellite Antenna Performance Gain and Efficiency (GNSS L1)

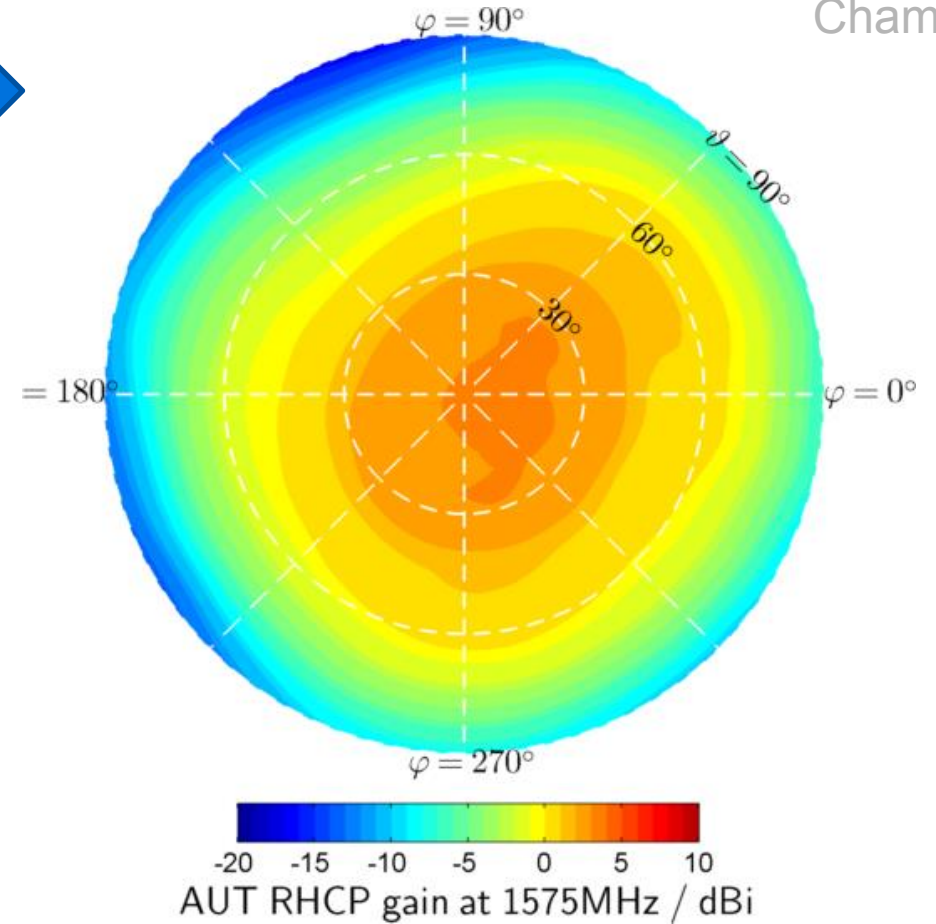
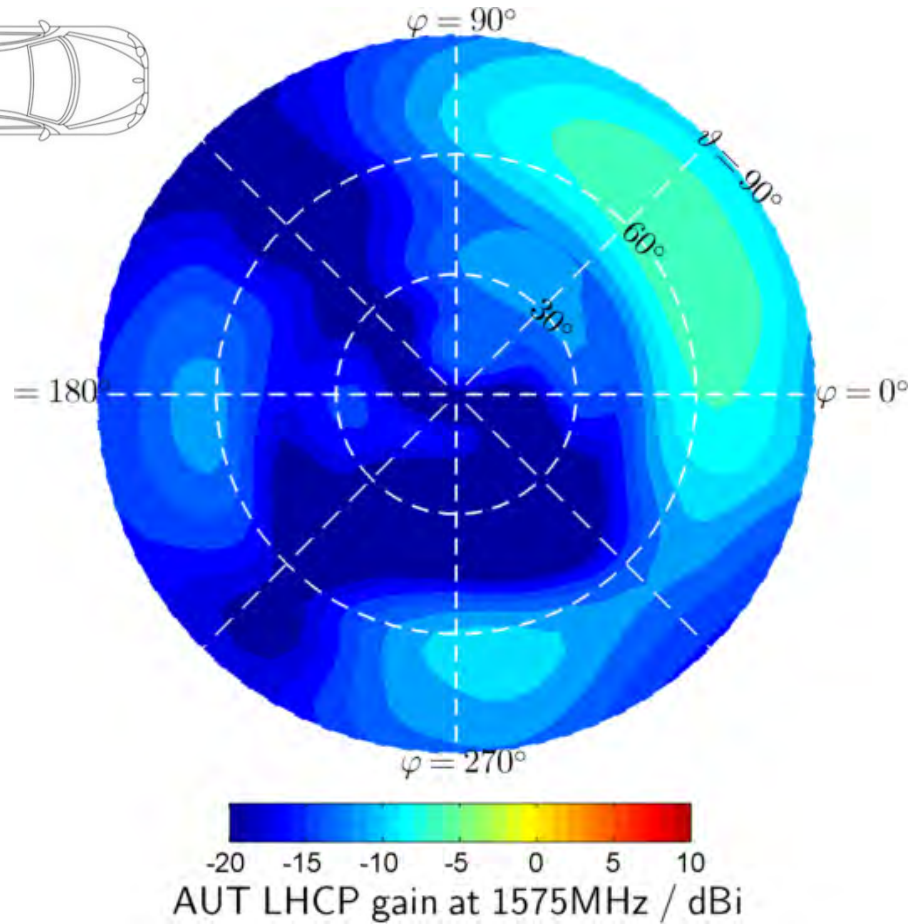
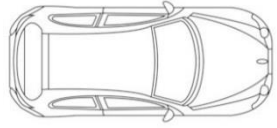


2.3 Variant E: Satellite Antenna Performance Gain and Efficiency (GNSS L1)



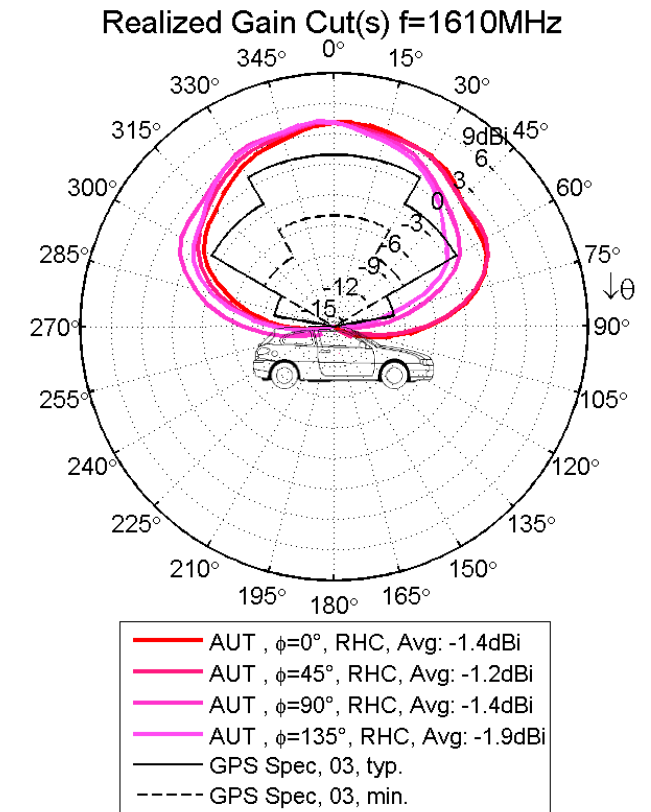
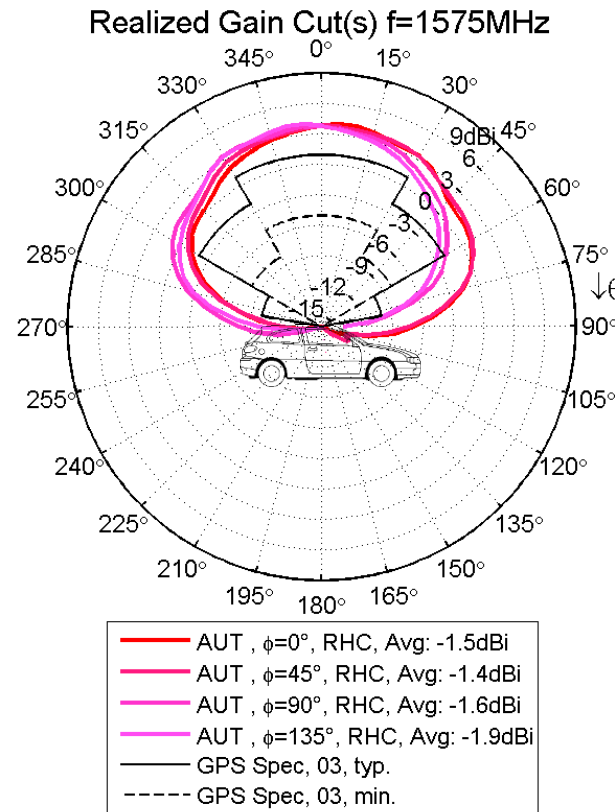
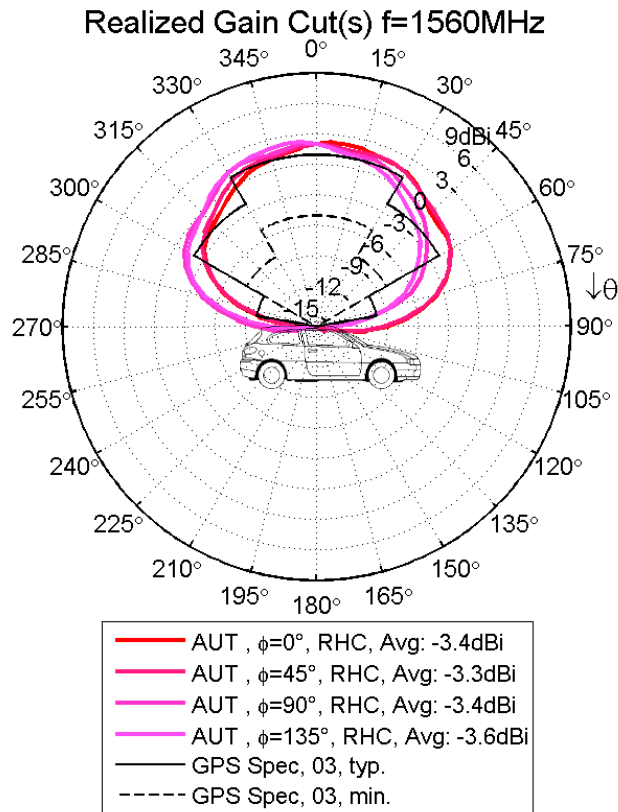
2.3 Variant E: Satellite Antenna Performance 3D-Chart (GNSS L1)

Chamber



2.3 Variant E: Satellite Antenna Performance Gain-Cuts (GNSS L1)

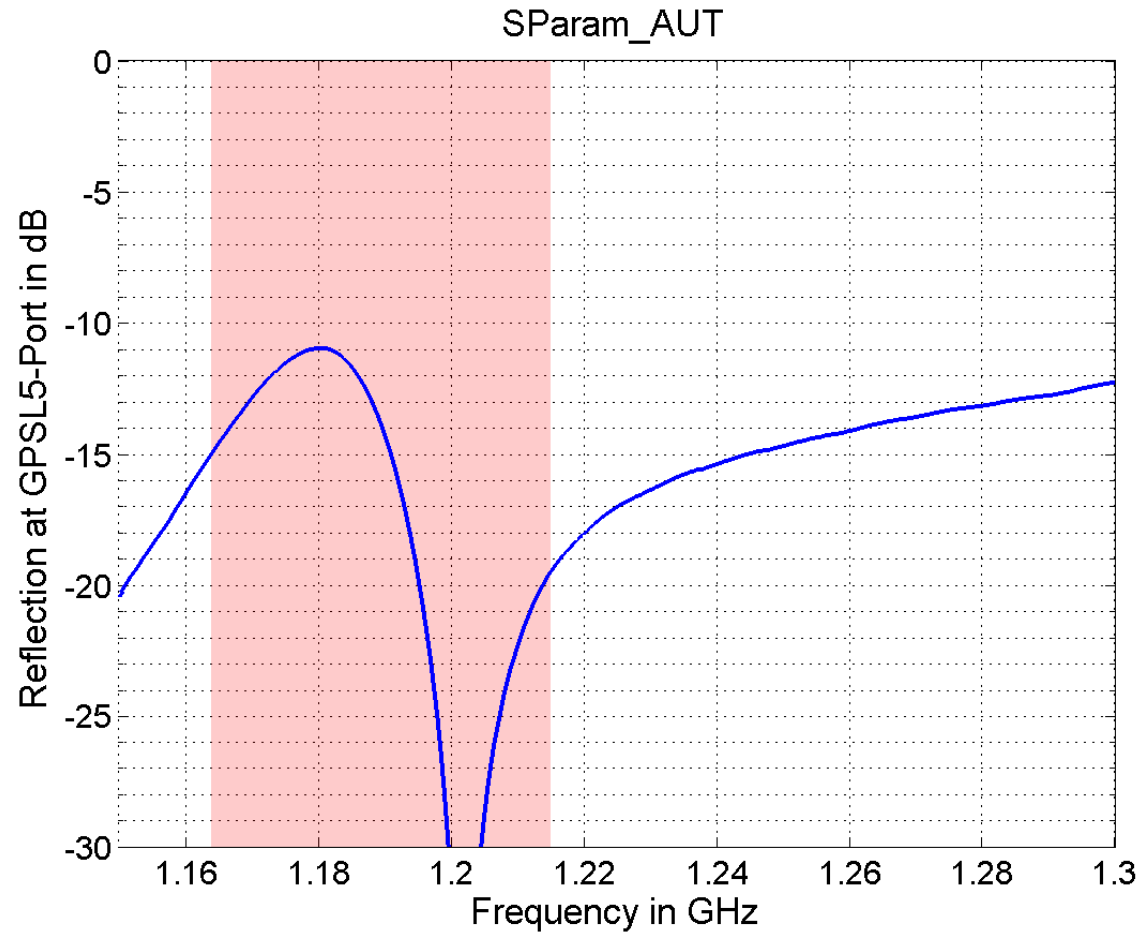
Chamber



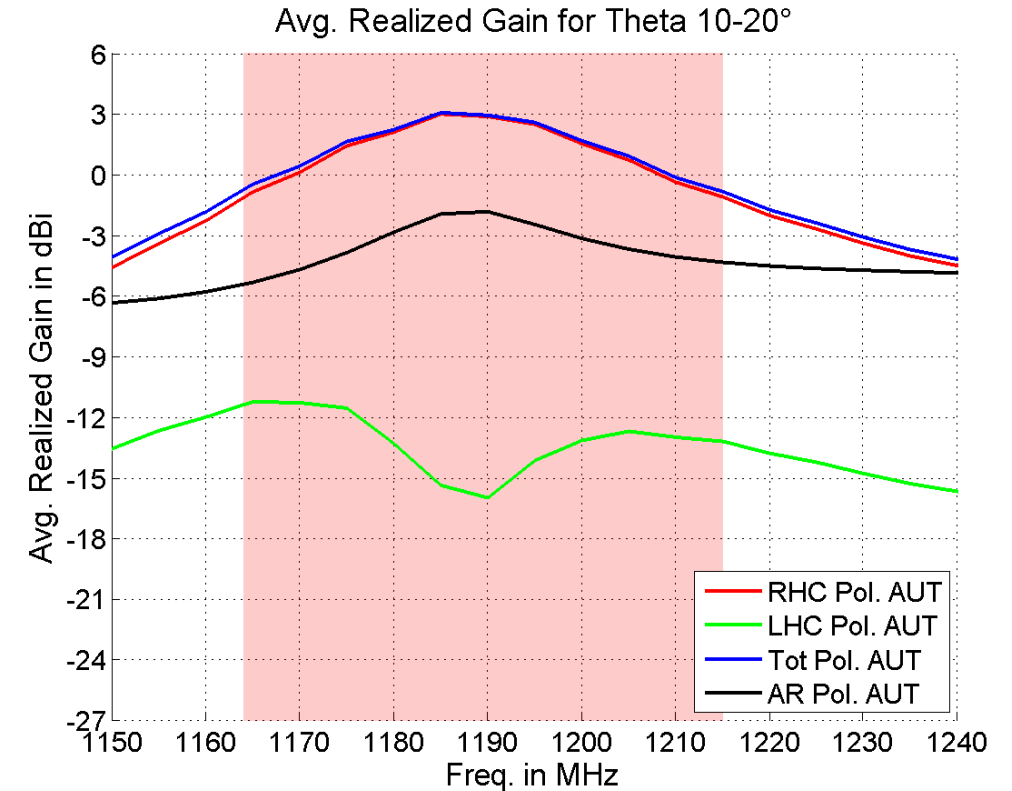
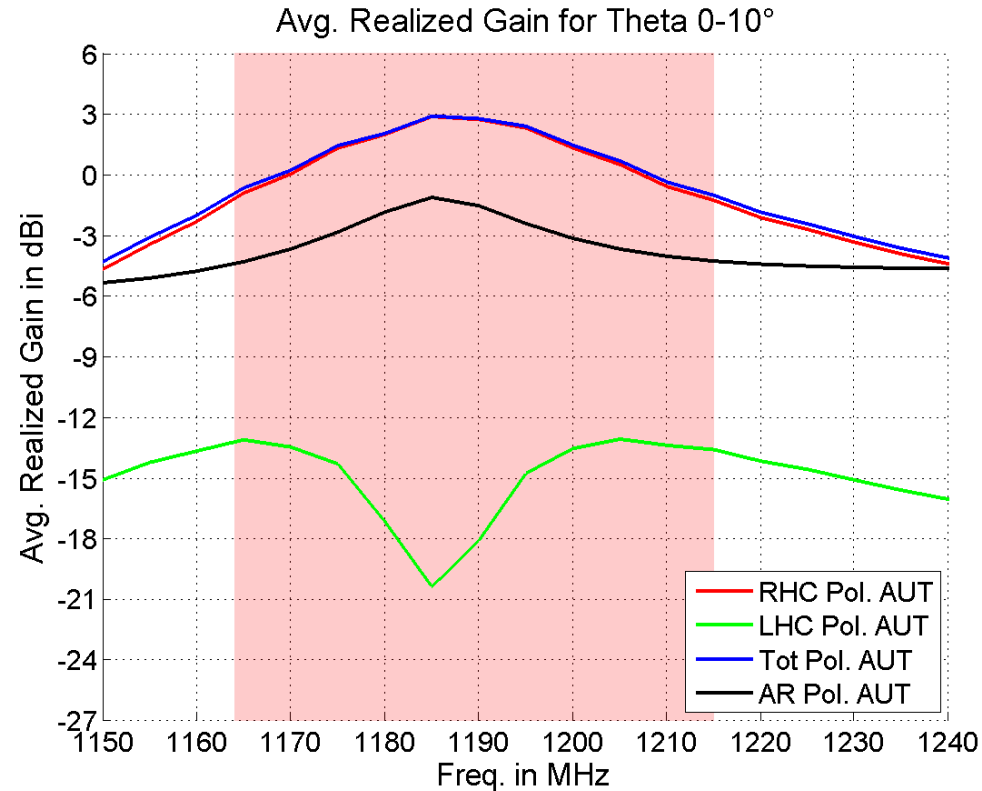
2.4 GNSS L2



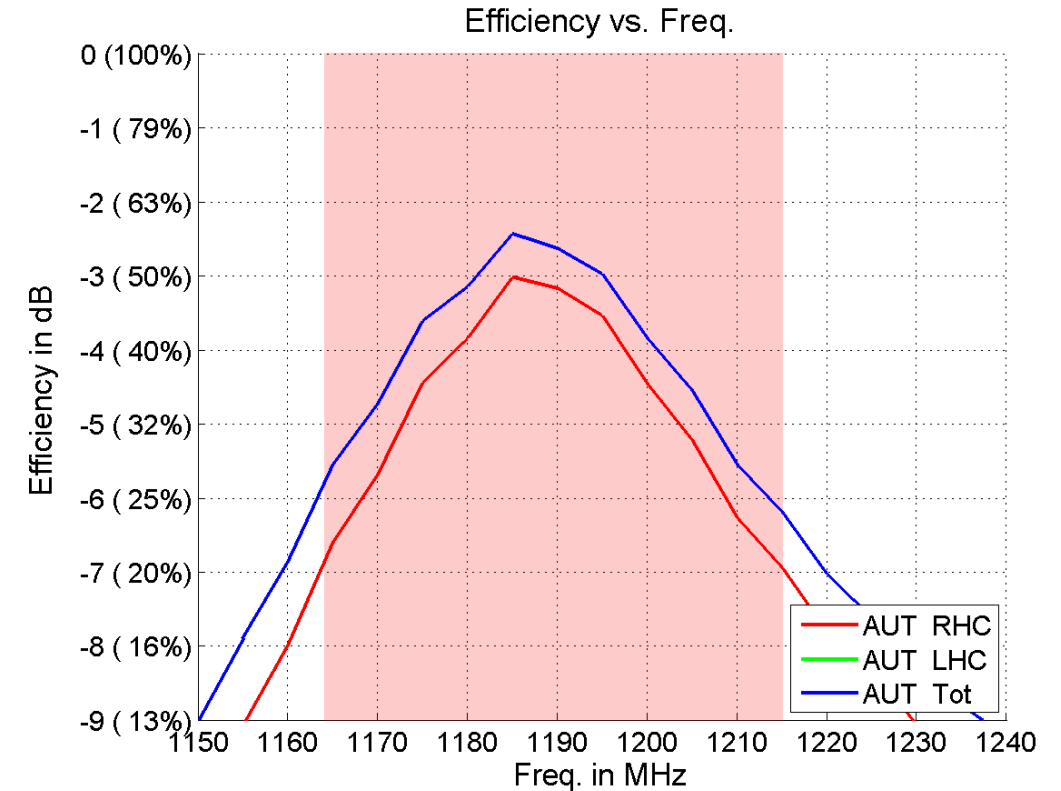
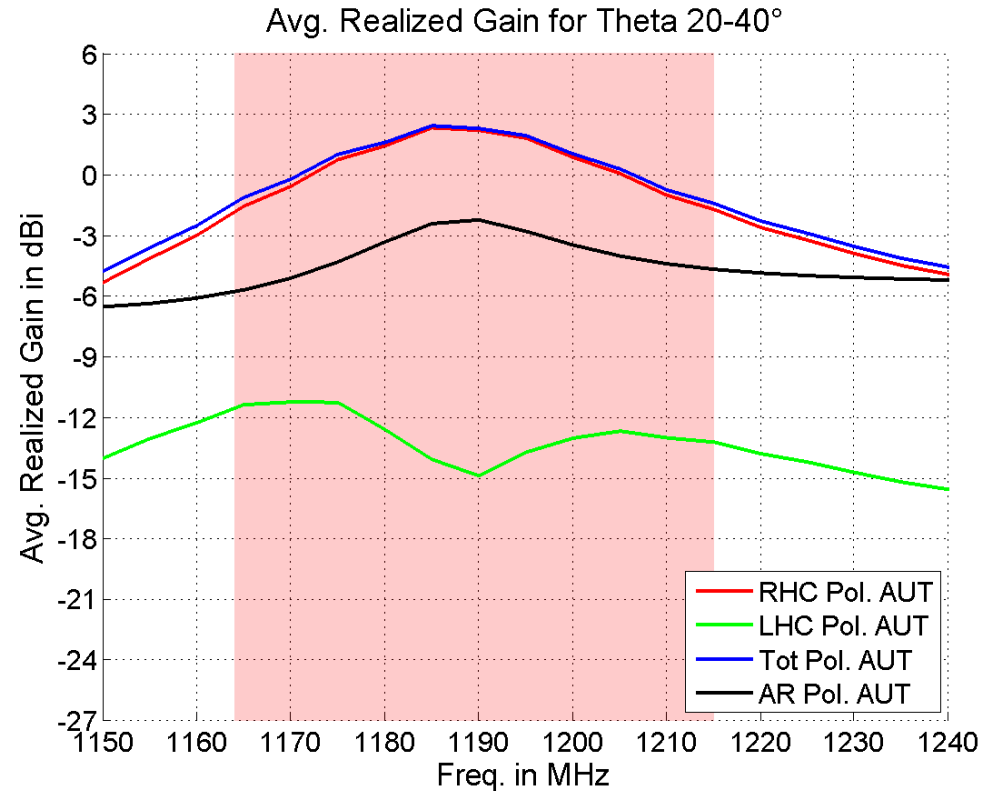
2.4 Variant E: Satellite Antenna Performance Matching (GNSS L2)



2.4 Variant E: Satellite Antenna Performance Gain and Efficiency (GNSS L2)

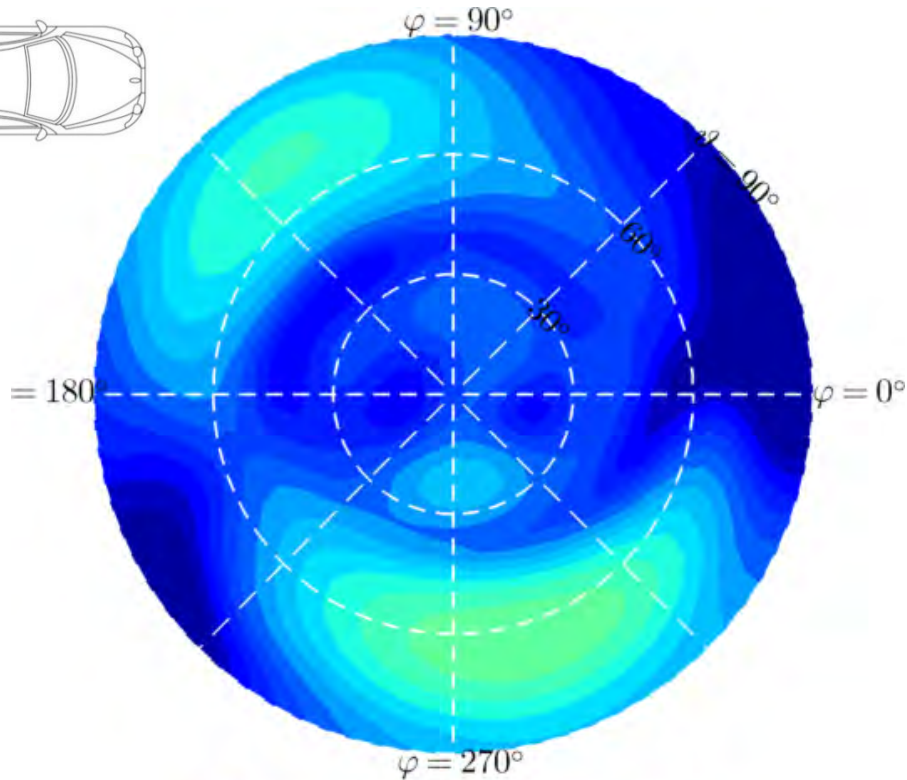
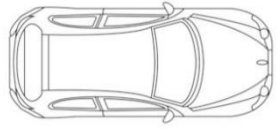


2.4 Variant E: Satellite Antenna Performance Gain and Efficiency (GNSS L2)

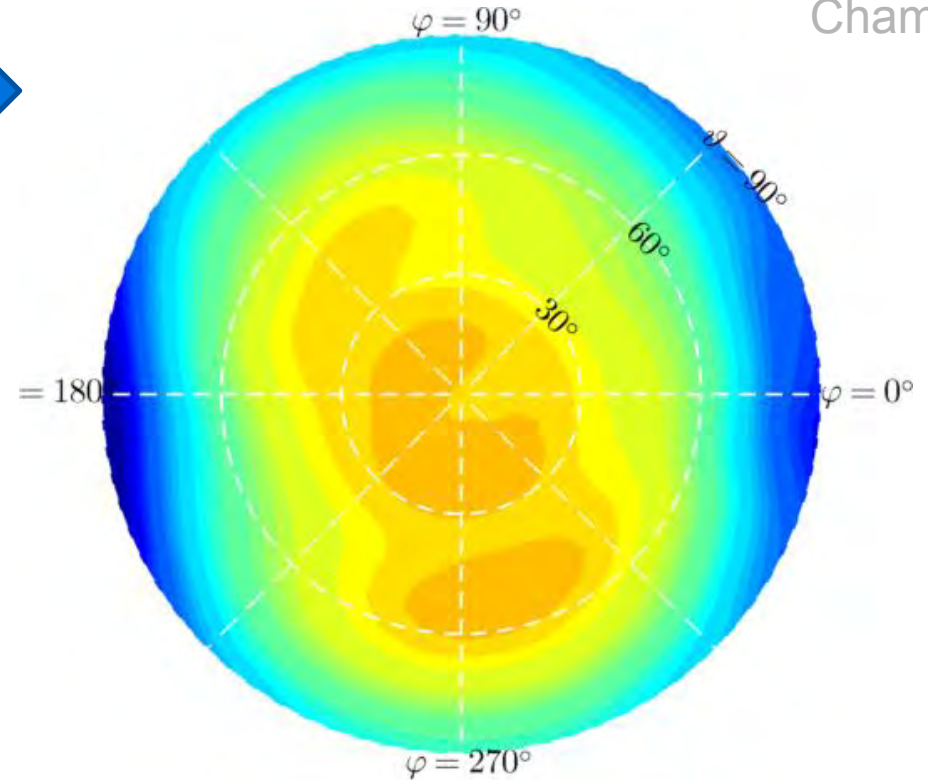


2.4 Variant E: Satellite Antenna Performance 3D-Chart (GNSS L2)

Chamber



-20 -15 -10 -5 0 5 10
AUT LHCP gain at 1200MHz / dBi

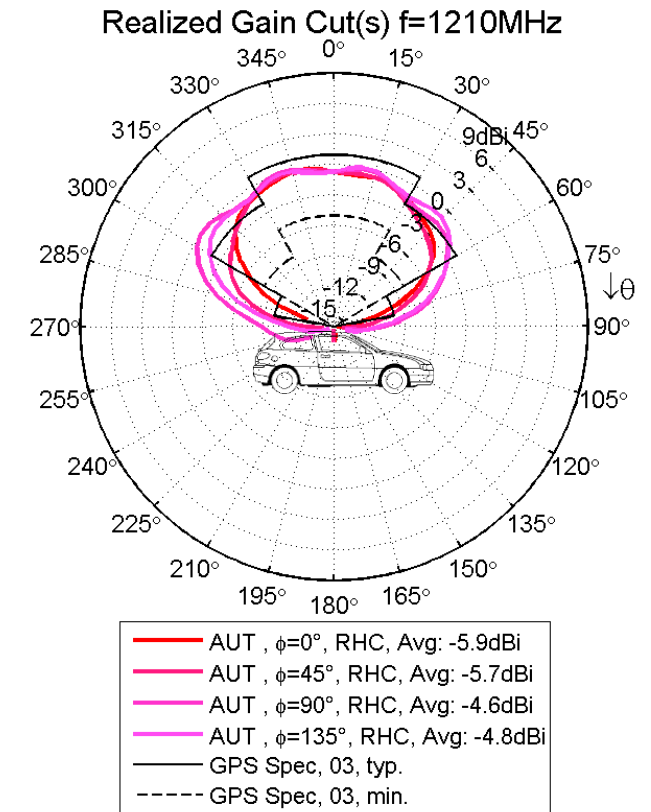
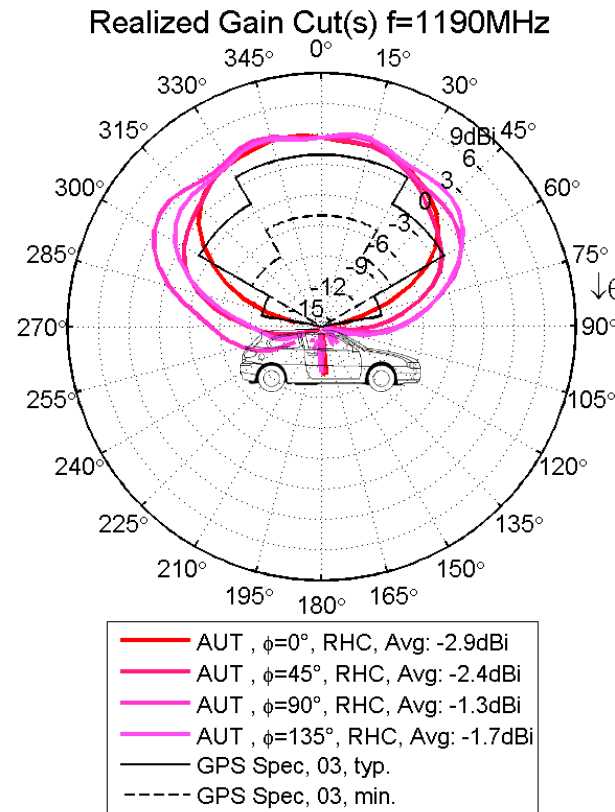
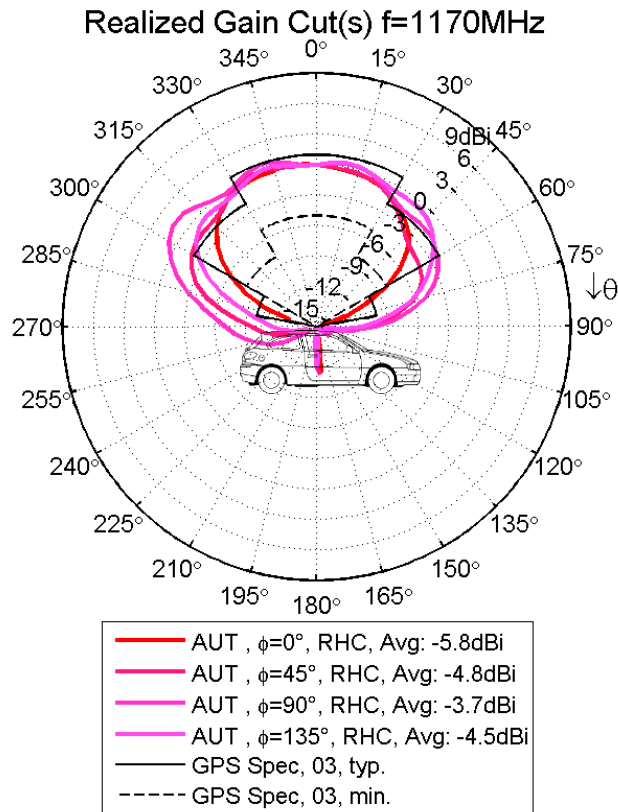


-20 -15 -10 -5 0 5 10
AUT RHCP gain at 1200MHz / dBi



2.4 Variant E: Satellite Antenna Performance Gain-Cuts (GNSS L2)

Chamber

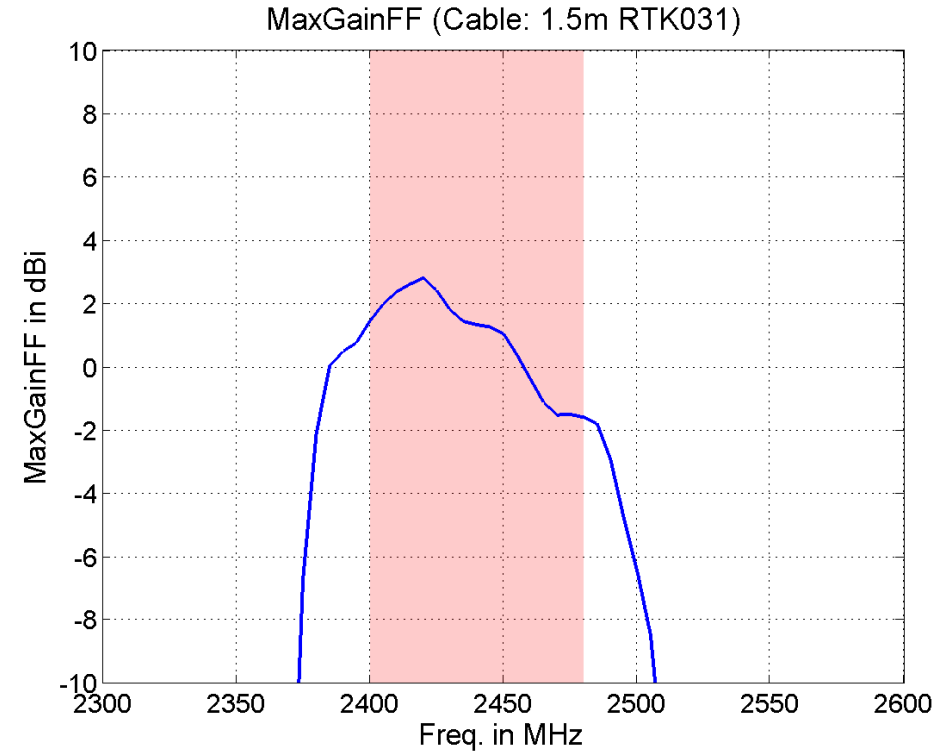
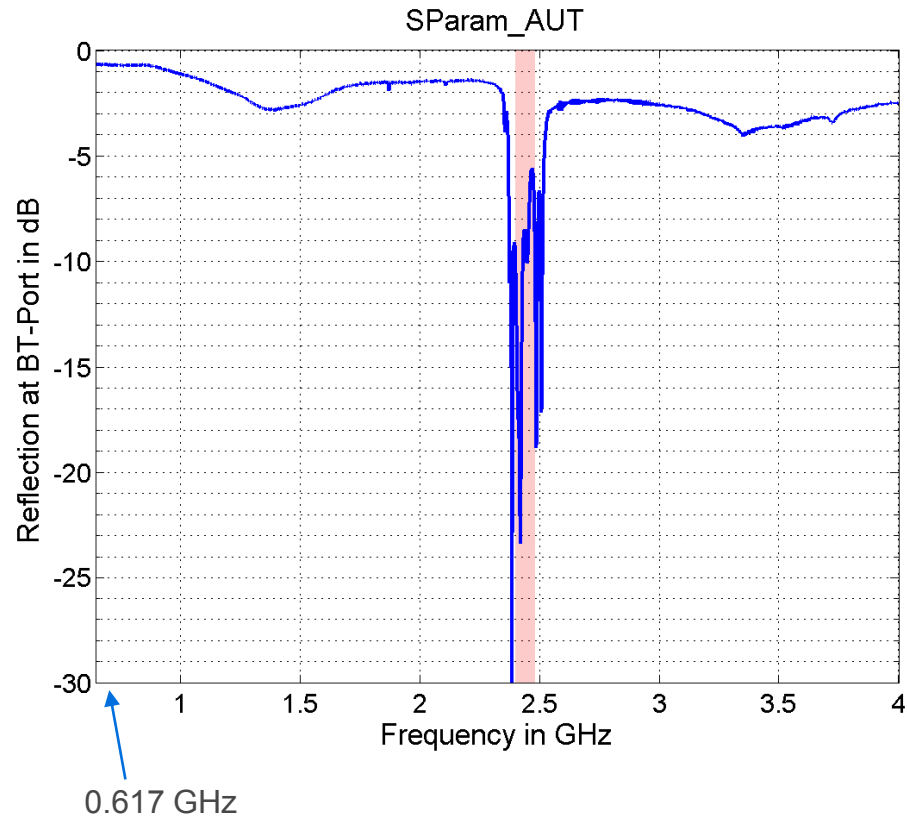


2.5 Bluetooth



2.5 Variant E: Bluetooth Antenna Performance Matching (BT)

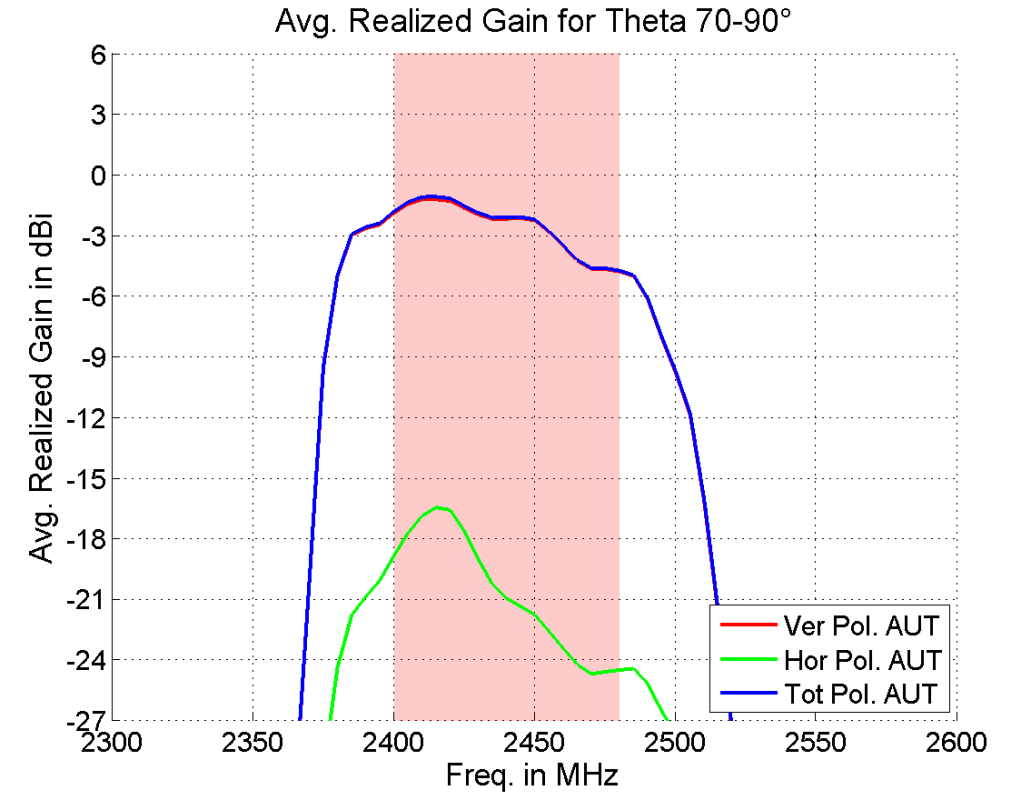
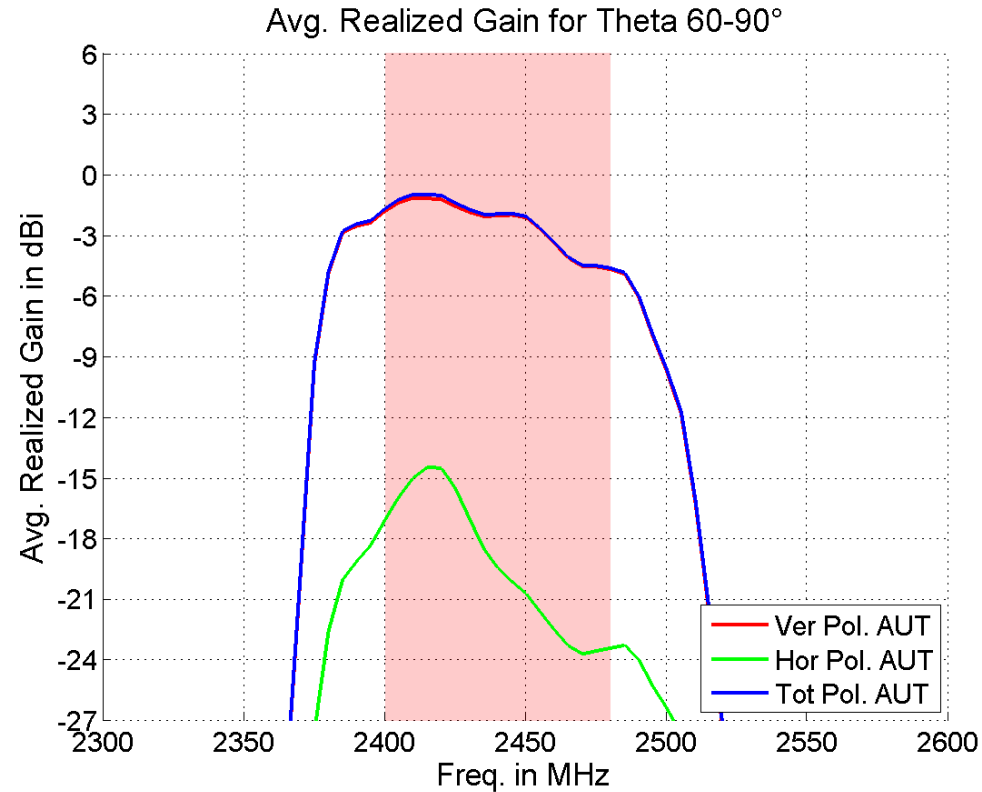
Chamber



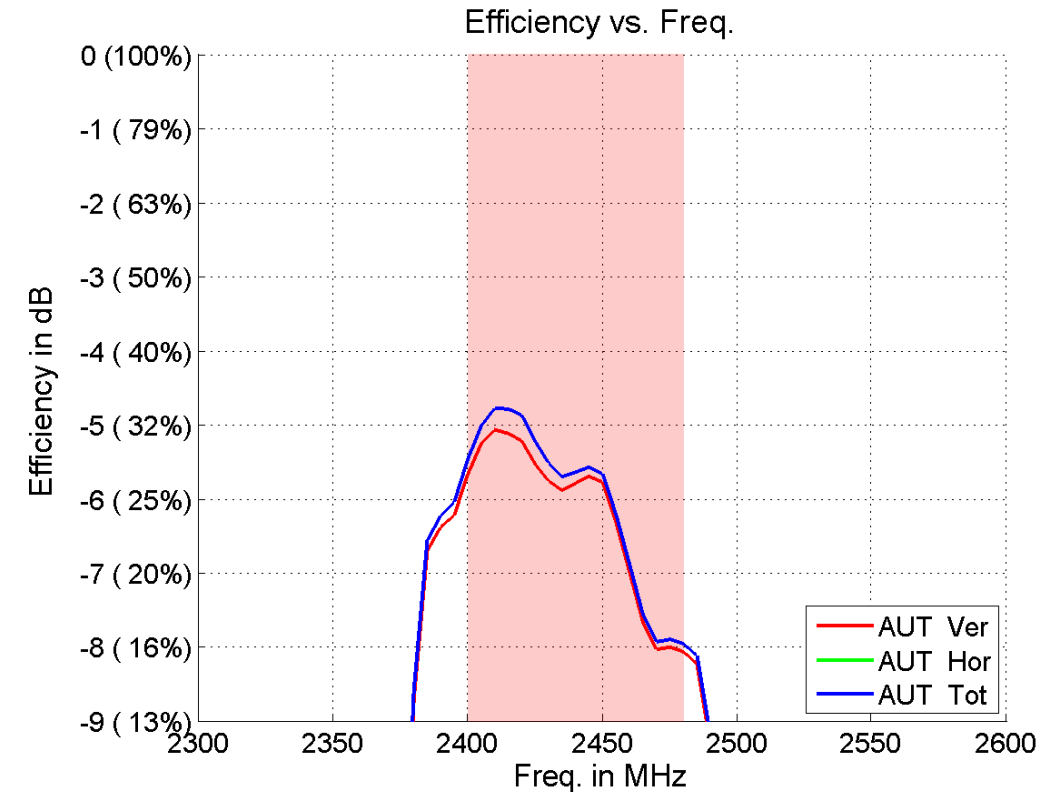
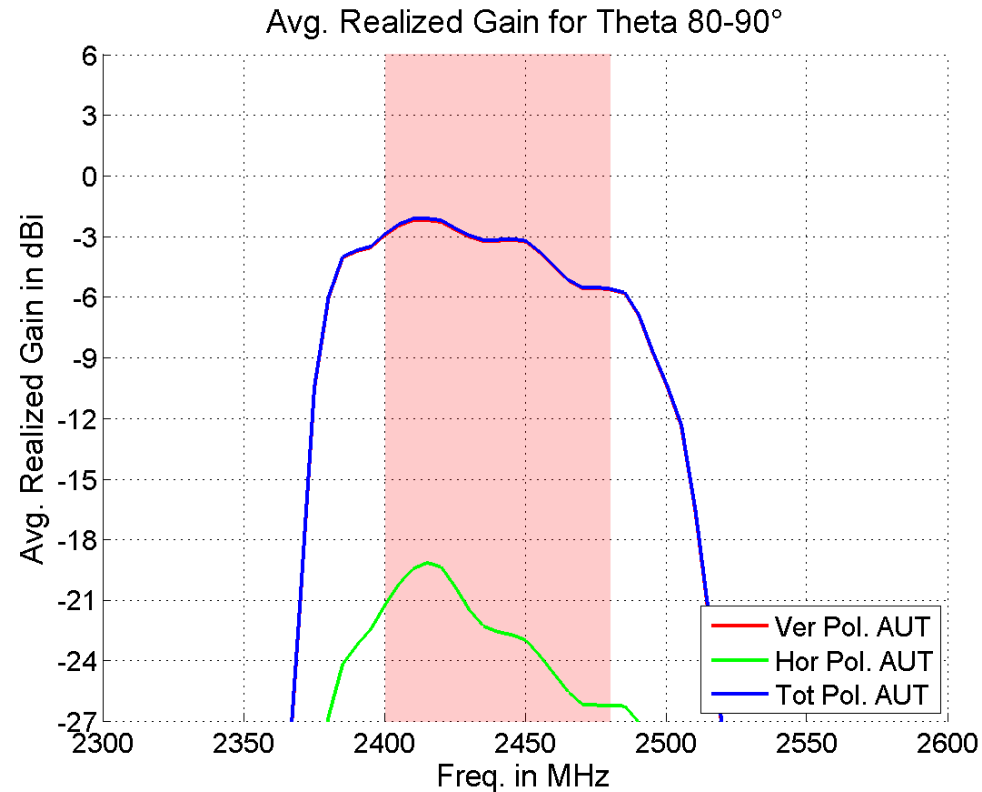
- The MaxGainFF-values are determined with 1.5m RTK031 cable (attenuation added to the measurement results).
- See attached file "Audi_CS_S13b_VariantE02_BT_gain_maxFF.csv" for the equivalent raw MaxGainFF-data.



2.5 Variant E: Bluetooth Antenna Performance Gain and Efficiency (BT)

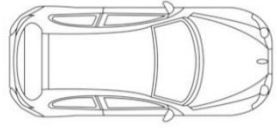


2.5 Variant E: Bluetooth Antenna Performance Gain and Efficiency (BT)

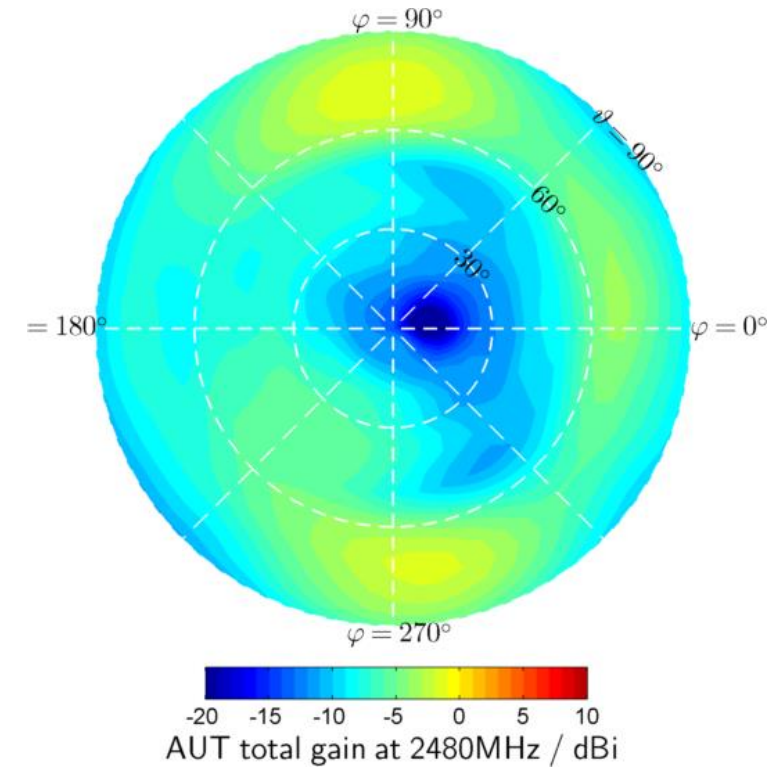
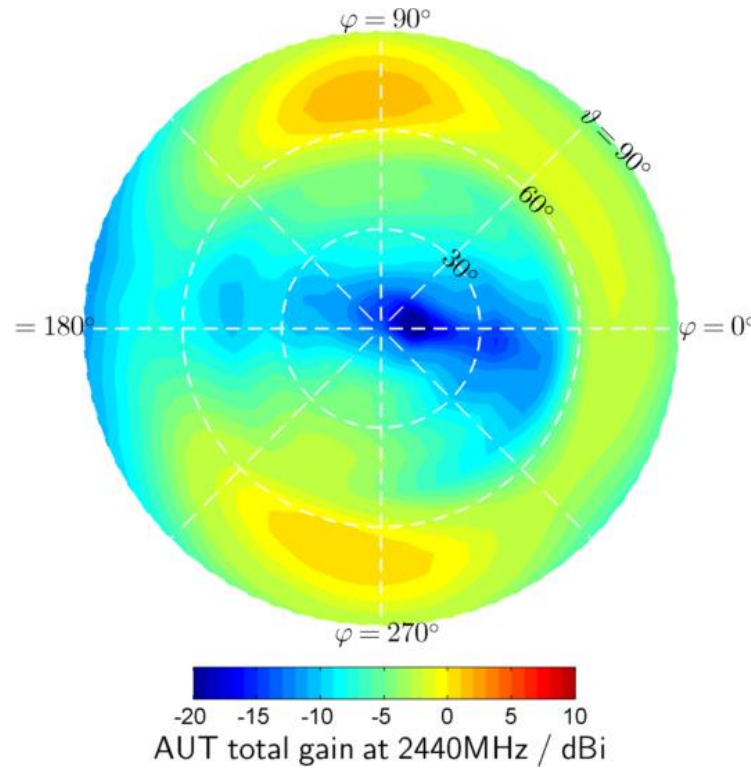
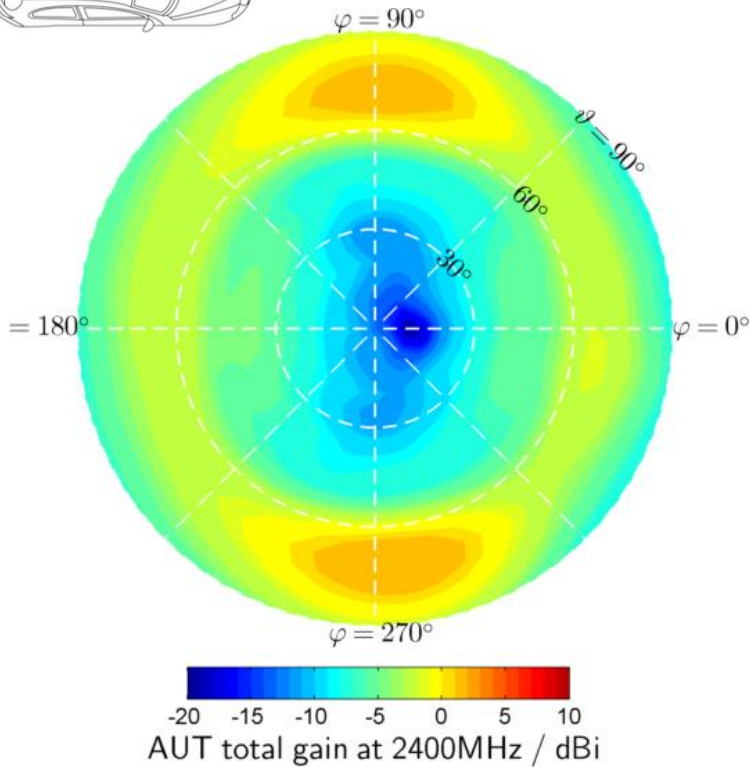


2.5 Variant E: Bluetooth Antenna Performance 3D-Chart (BT)

Chamber

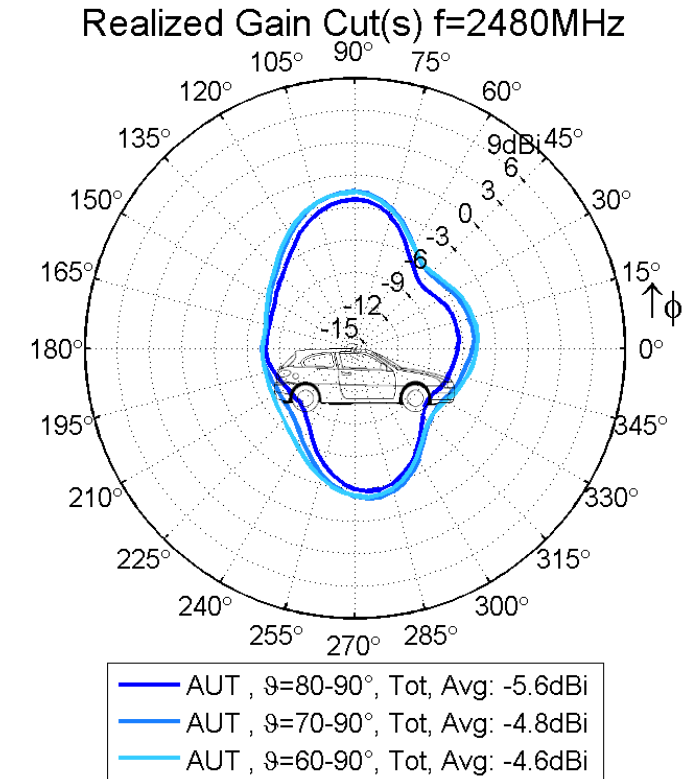
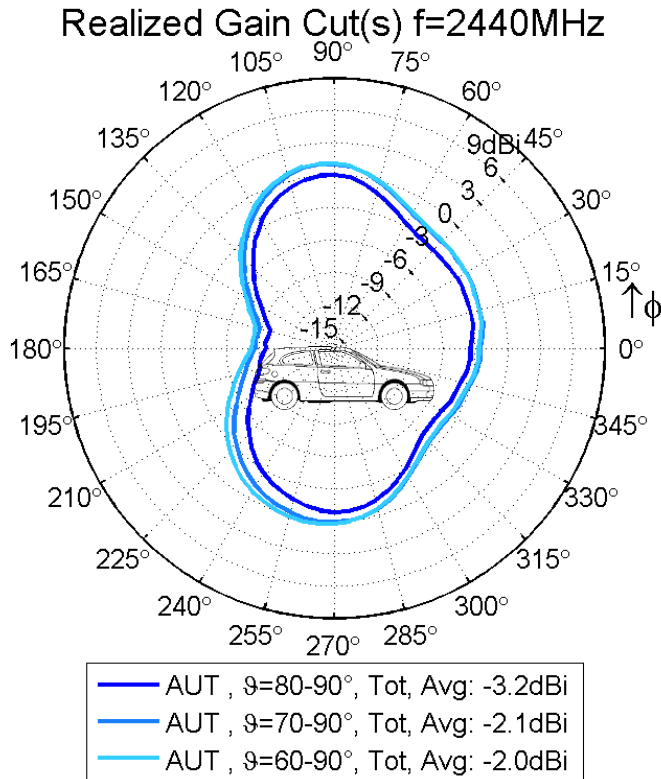
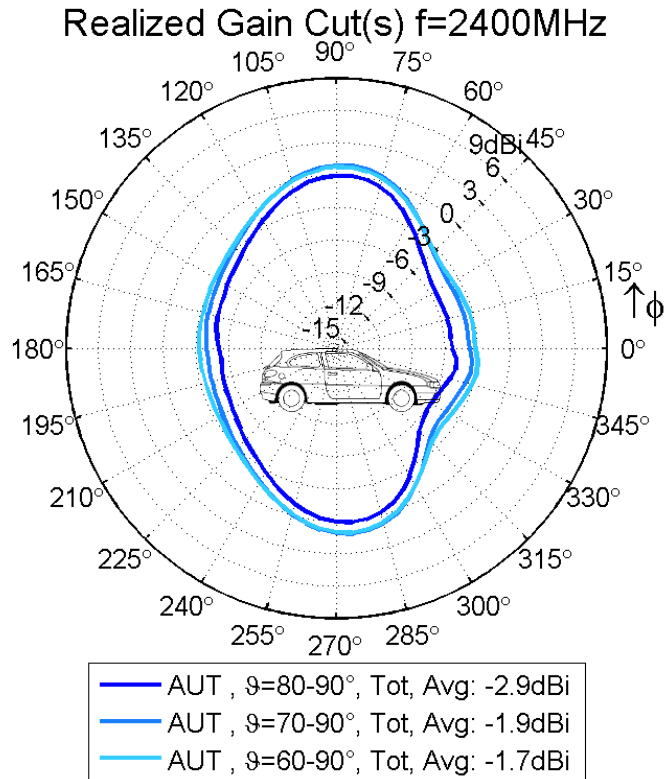


Driving Direction



2.5 Variant E: Bluetooth Antenna Performance Gain-Cuts (BT)

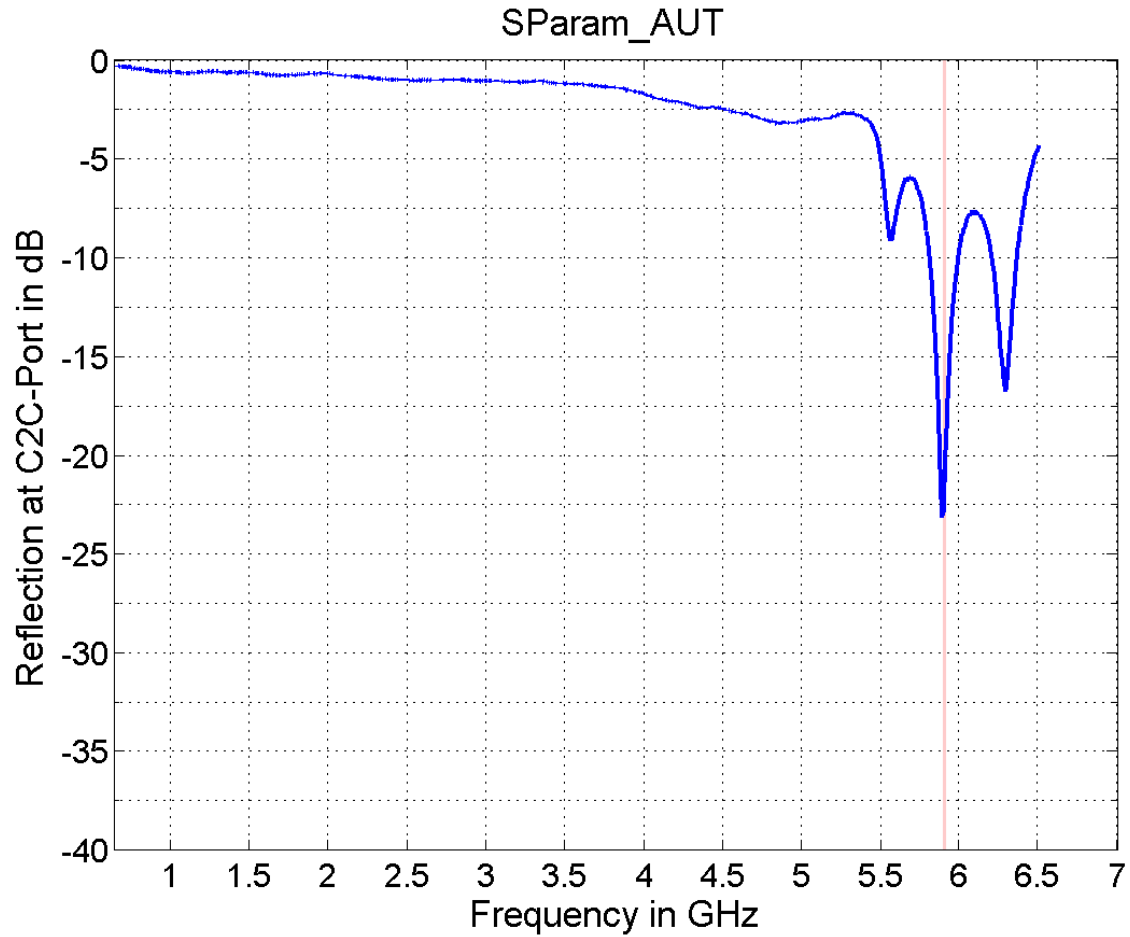
Chamber



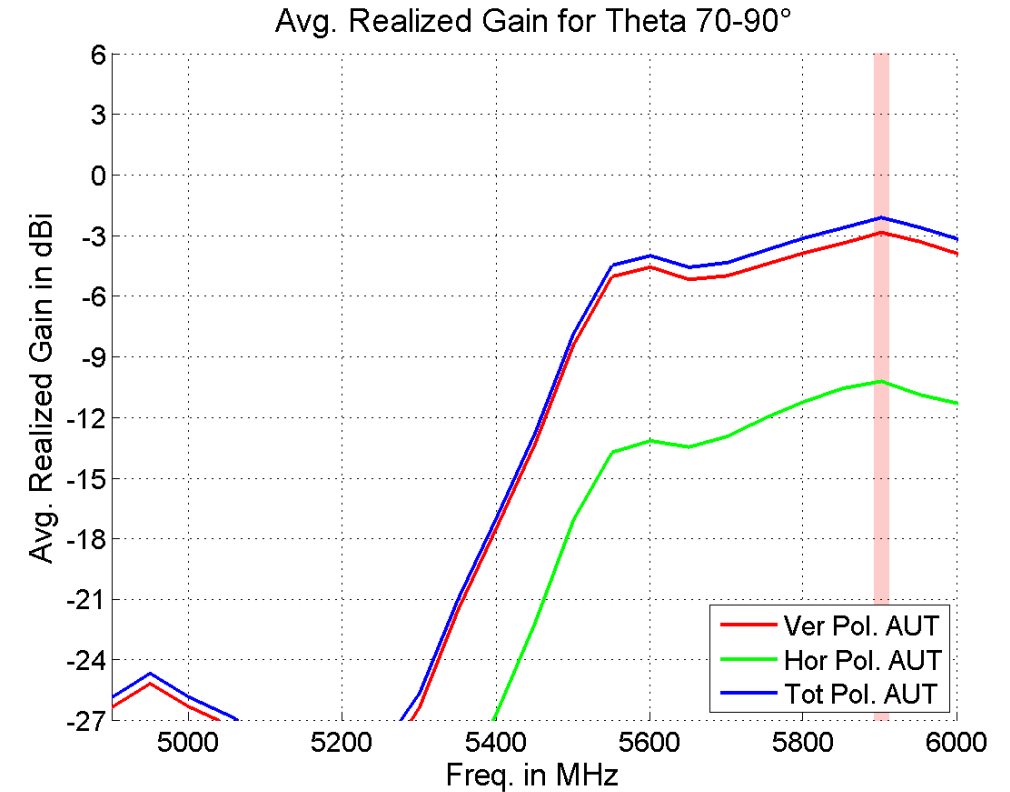
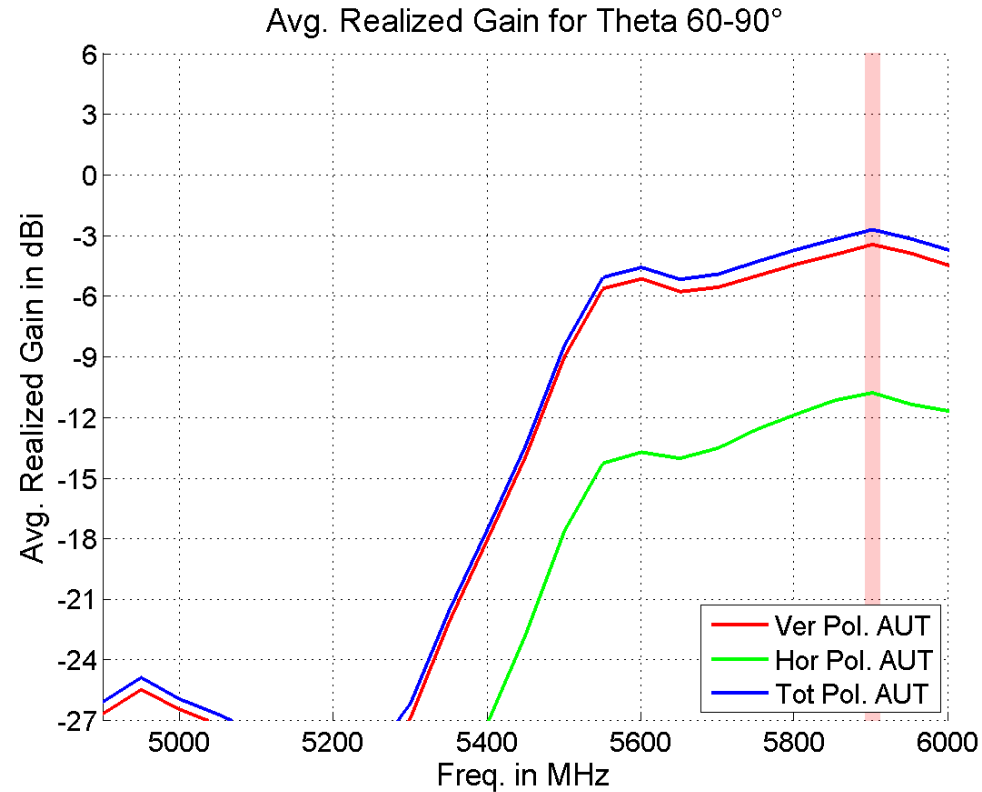
2.6 CV2X



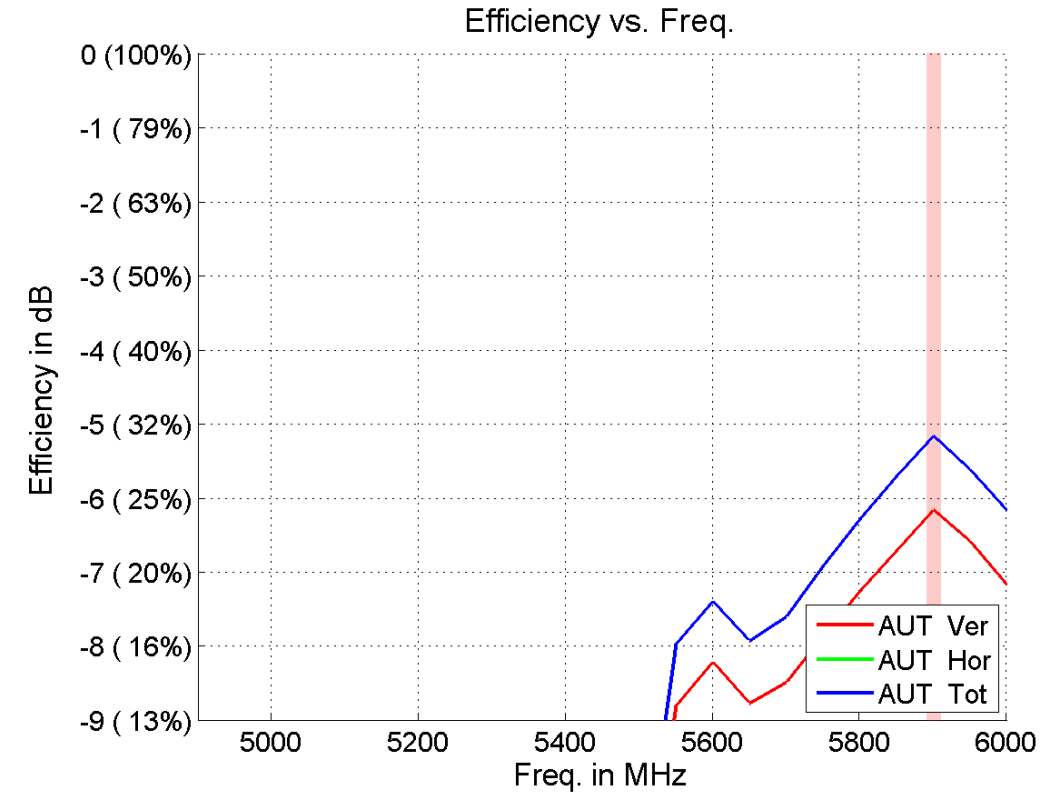
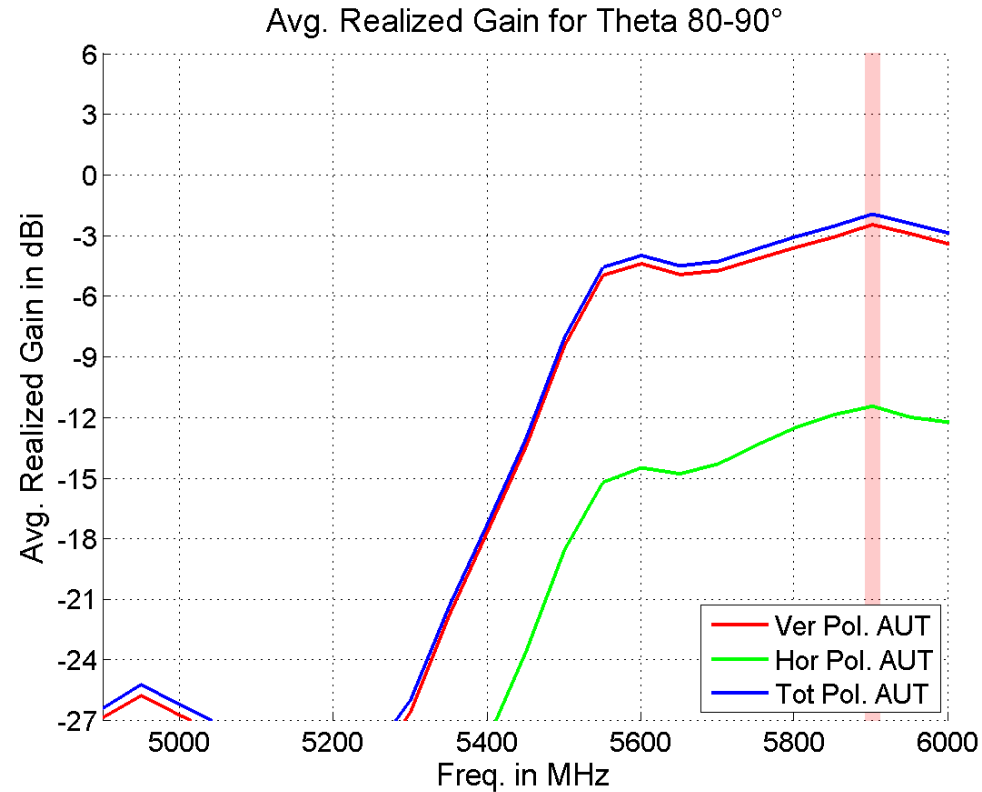
2.6 Variant E: CV2X Antenna Performance Matching (CV2X)



2.6 Variant E: CV2X Antenna Performance Gain and Efficiency (CV2X)

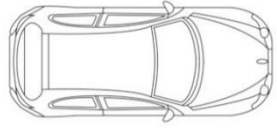


2.6 Variant E: CV2X Antenna Performance Gain and Efficiency (CV2X)

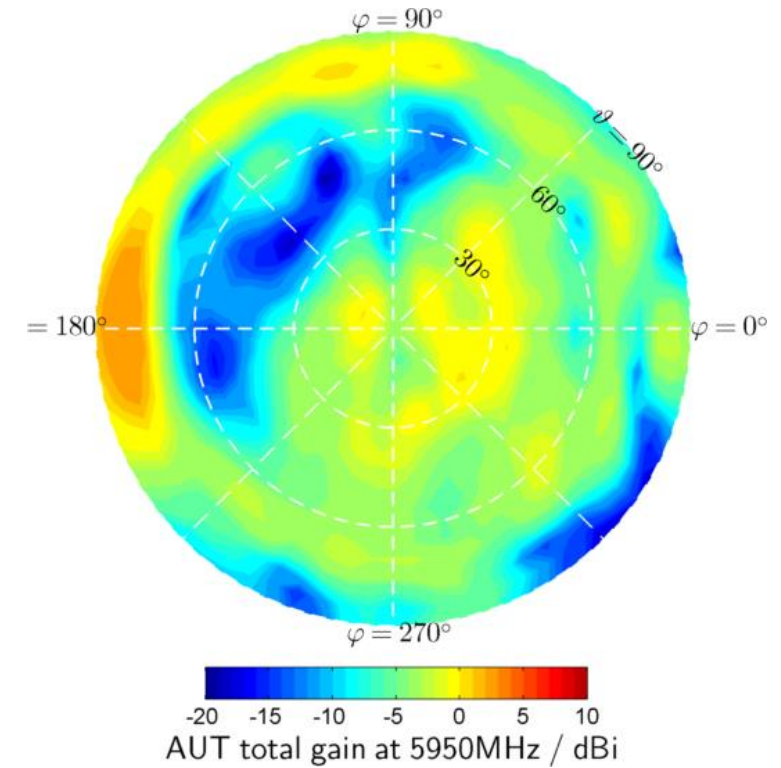
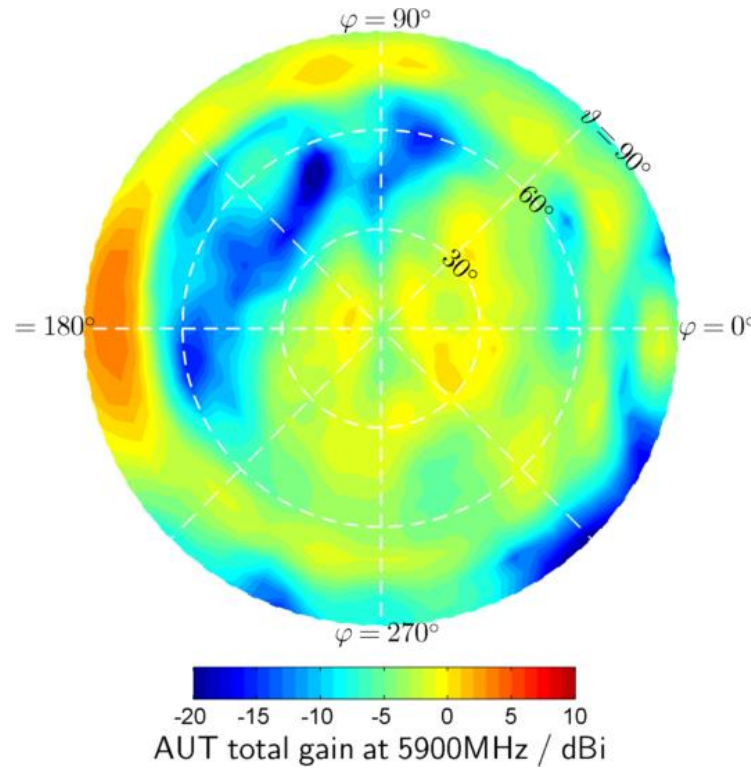
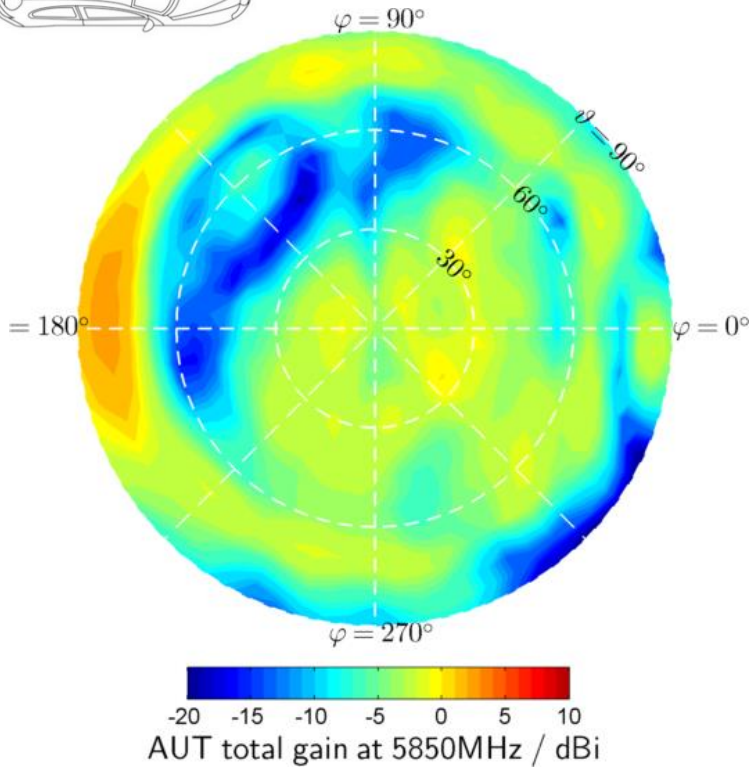


2.6 Variant E: CV2X Antenna Performance 3D-Chart (CV2X)

Chamber

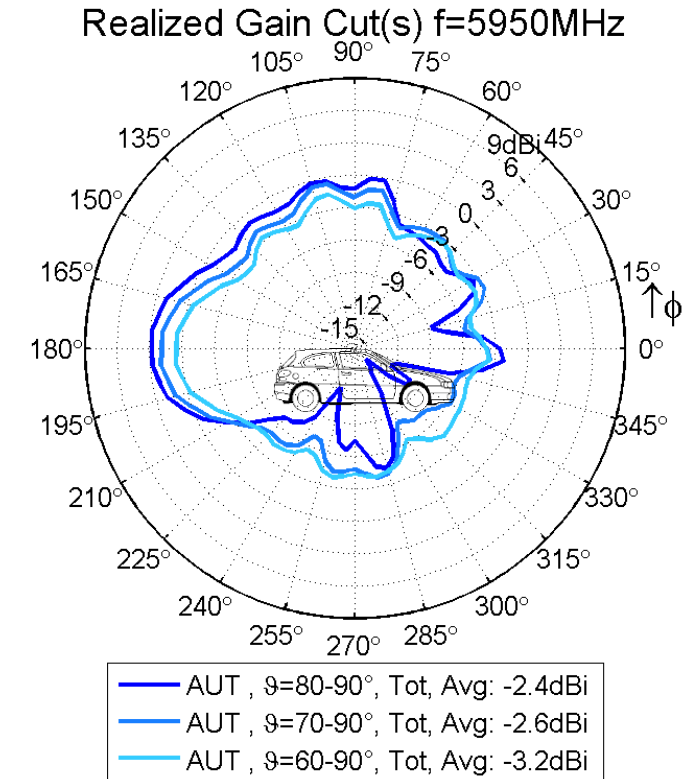
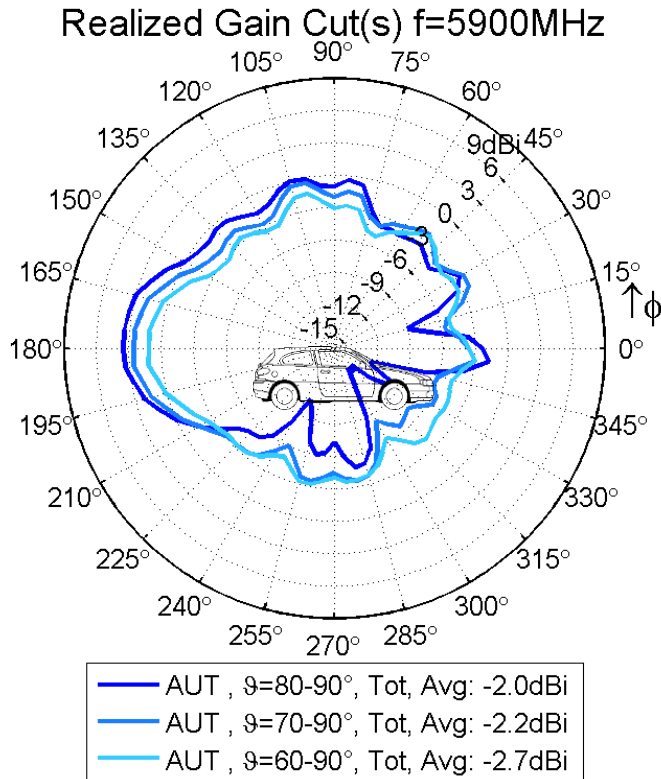
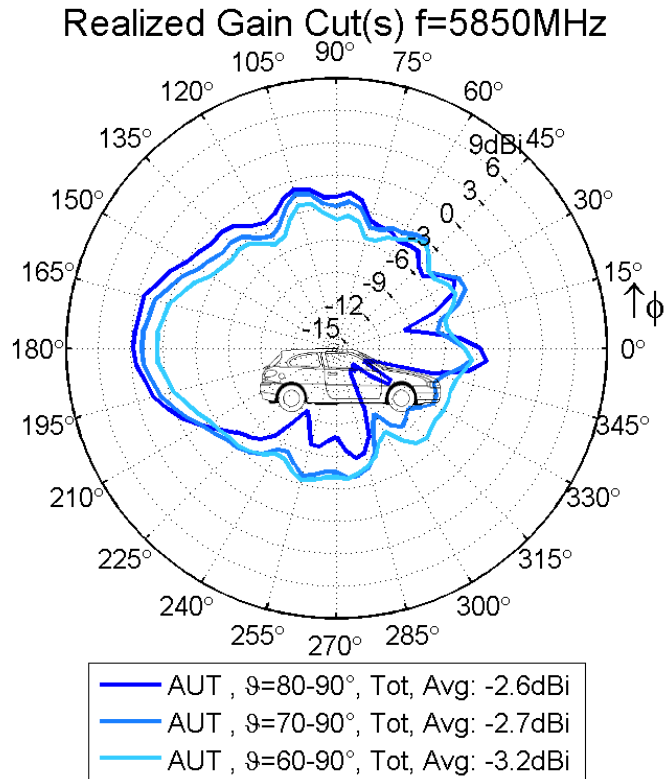


Driving Direction



2.6 Variant E: CV2X Antenna Performance Gain-Cuts (CV2X)

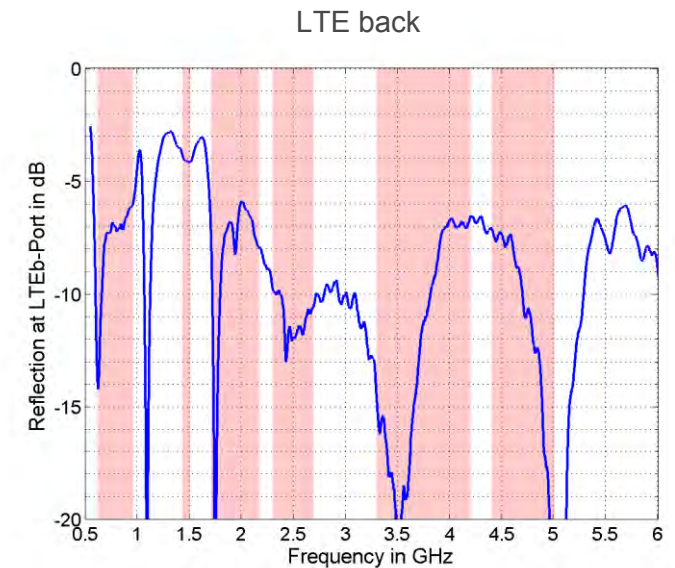
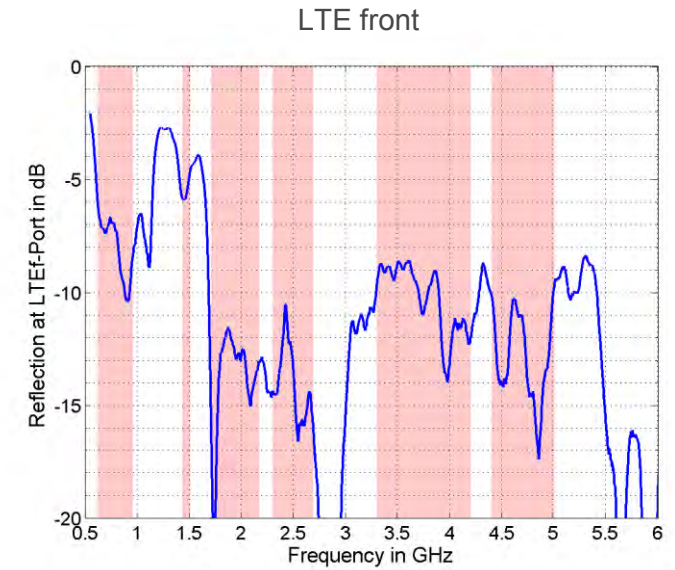
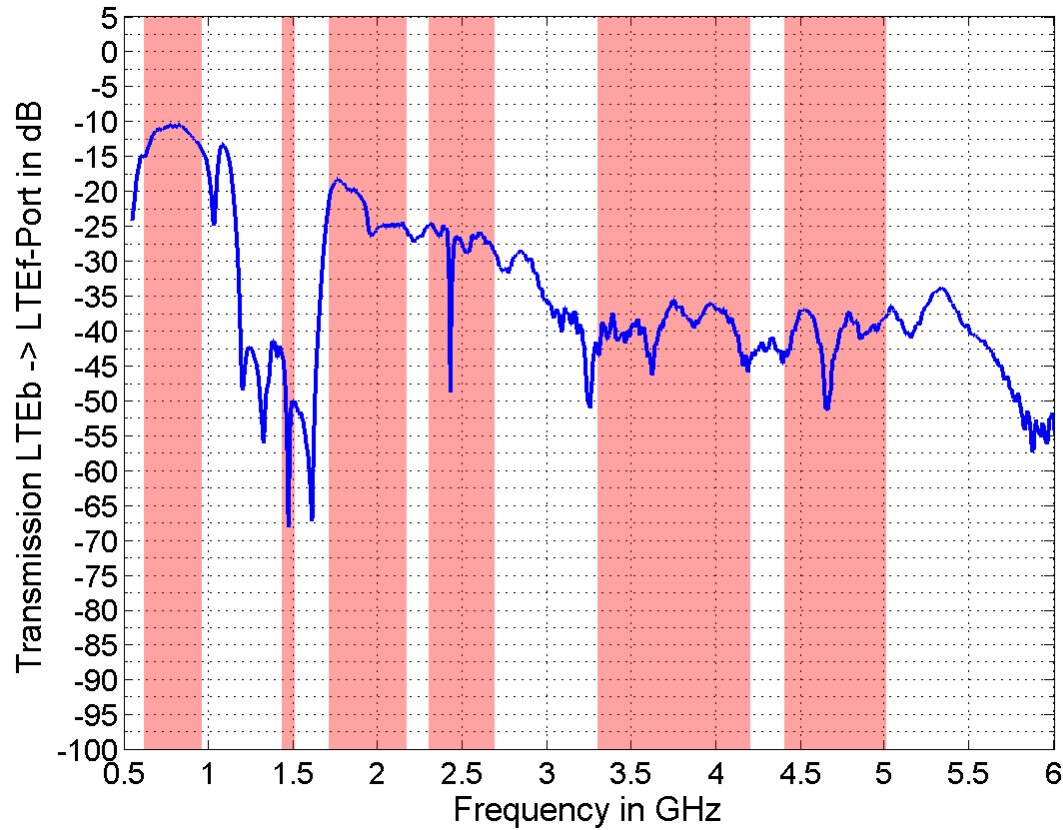
Chamber



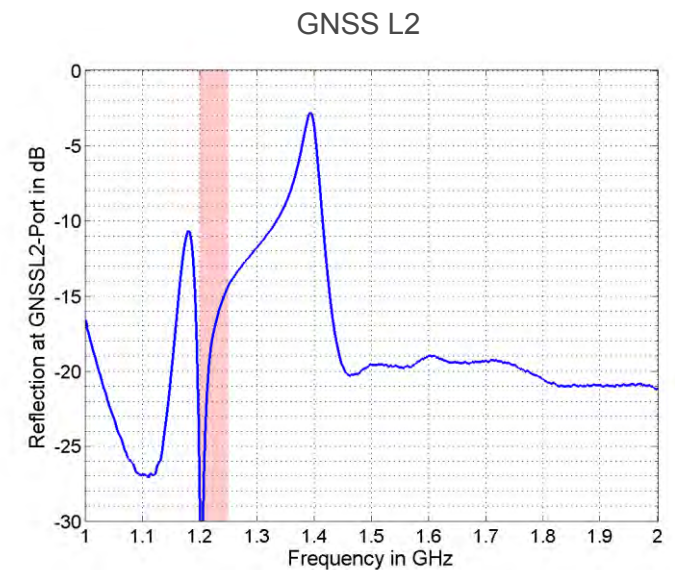
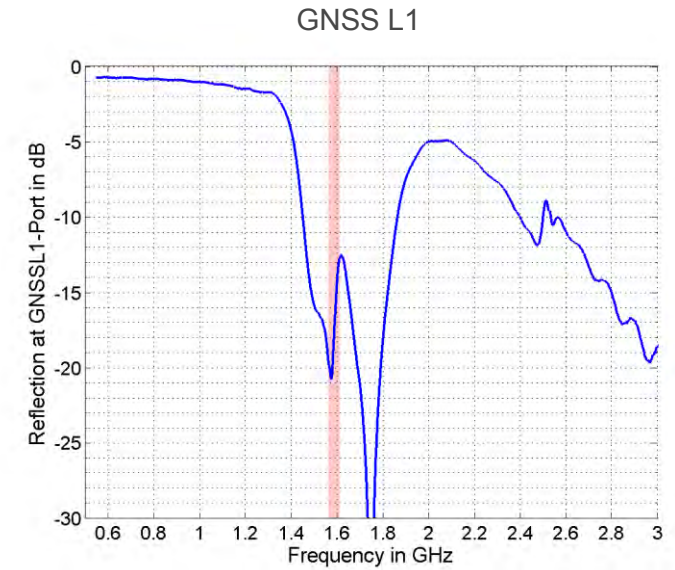
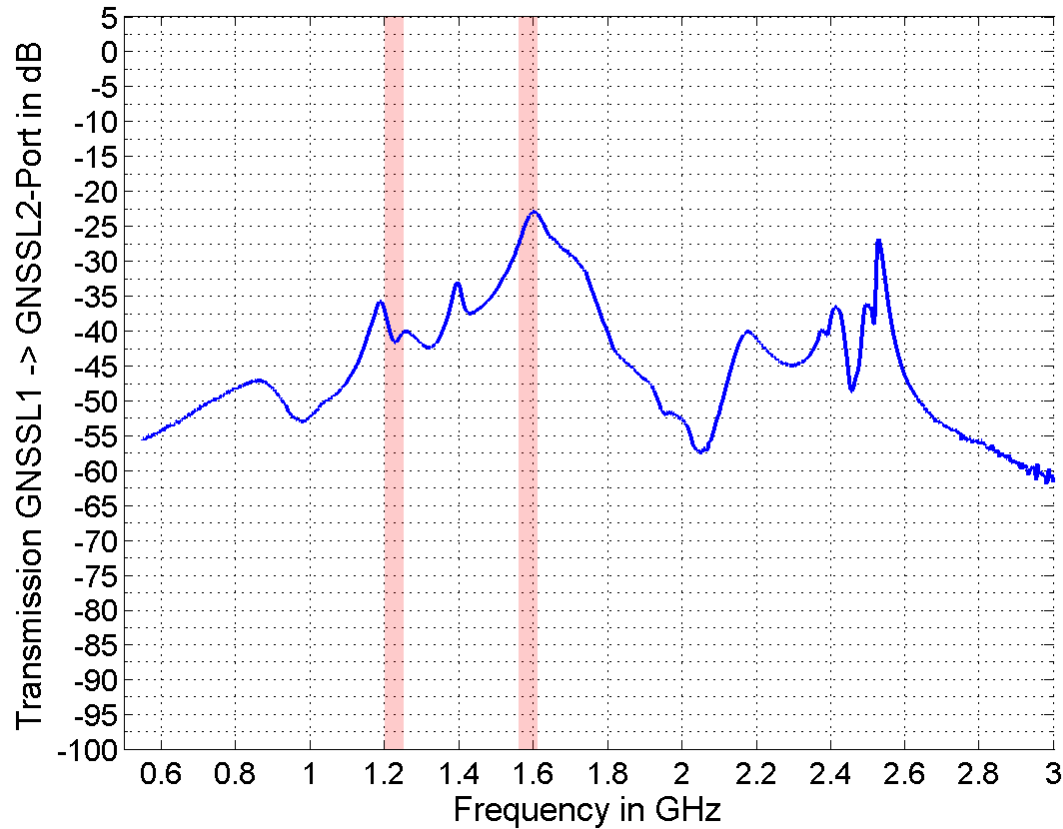
2.7 Decoupling



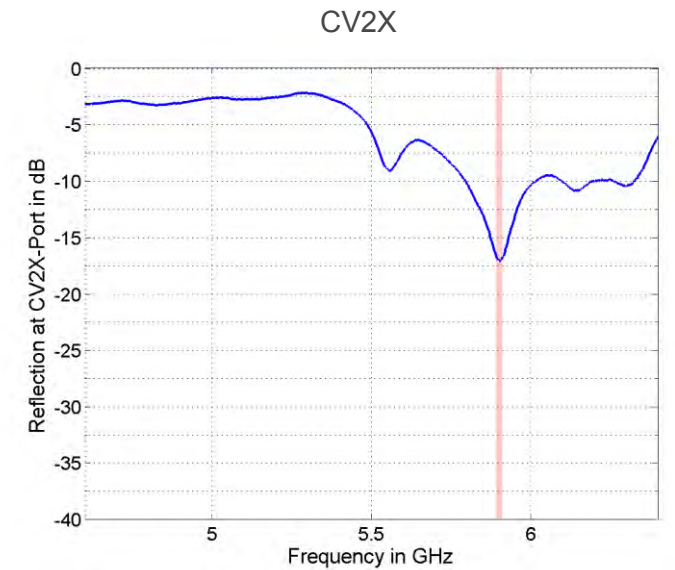
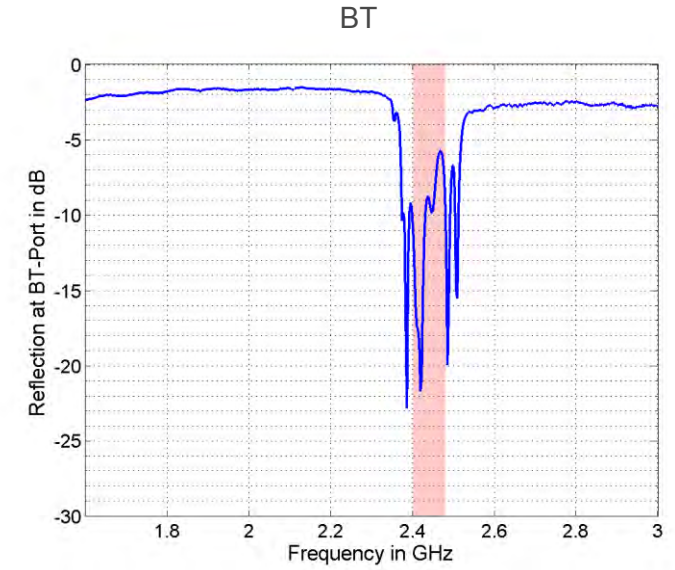
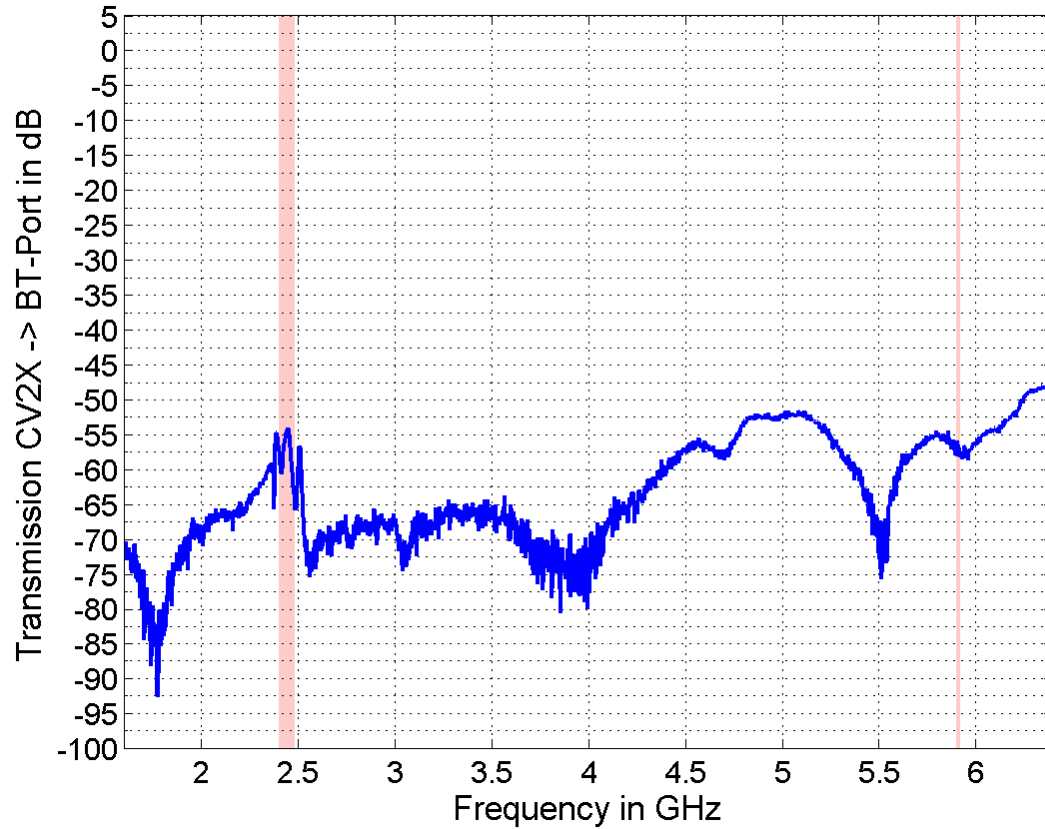
2.7 Variant E: Decoupling LTE front <=> LTE back



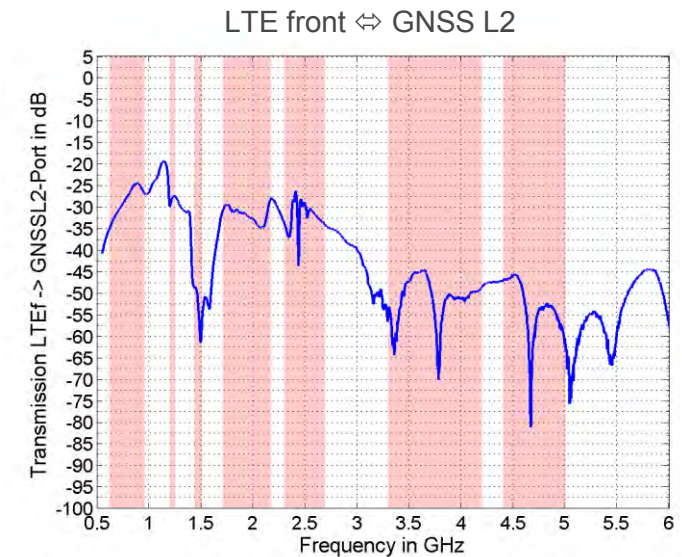
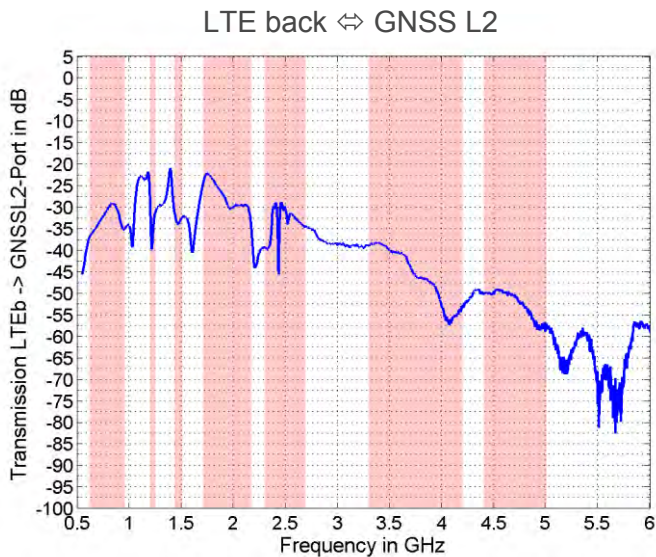
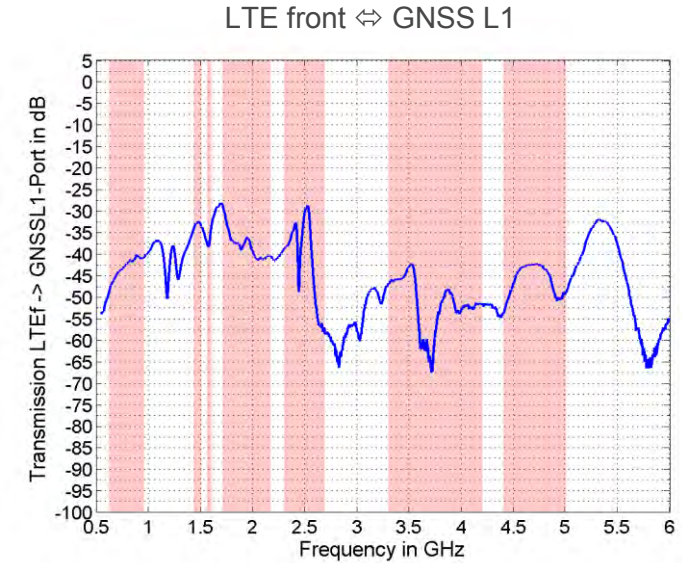
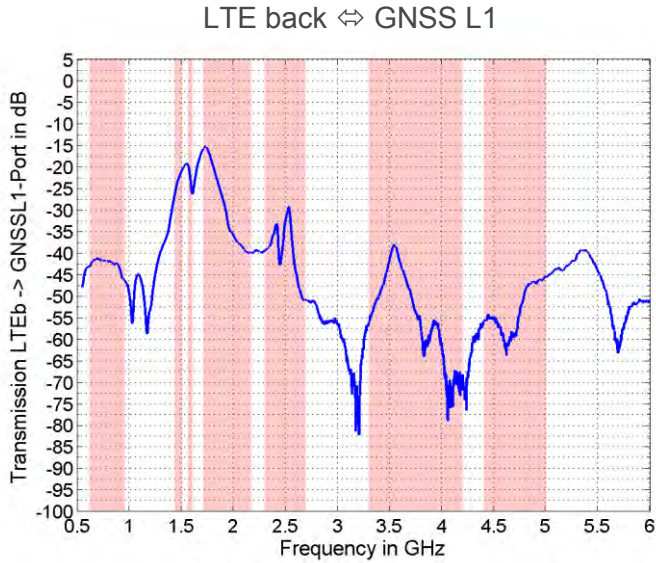
2.7 Variant E: Decoupling GNSS L1 \Leftrightarrow GNSS L2



2.7 Variant E: Decoupling BT <=> CV2X

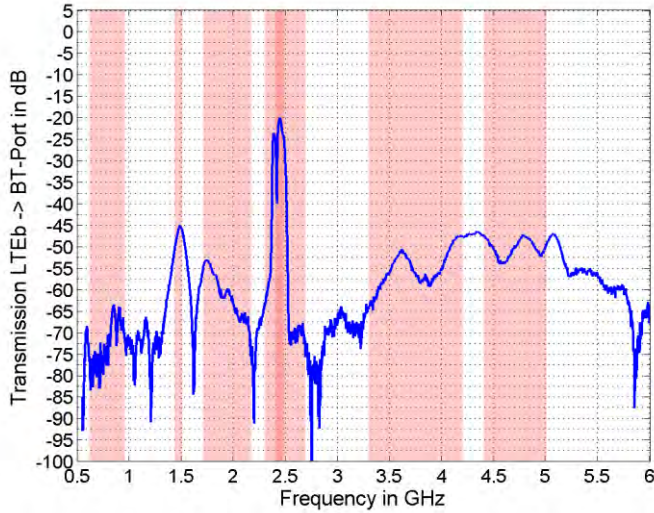


2.7 Variant E: Decoupling LTEs <=> SATs

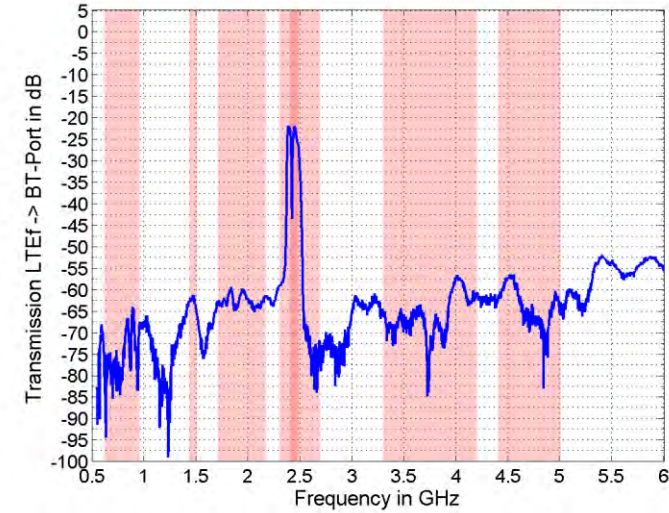


2.7 Variant E: Decoupling LTEs \Leftrightarrow BT / CV2X

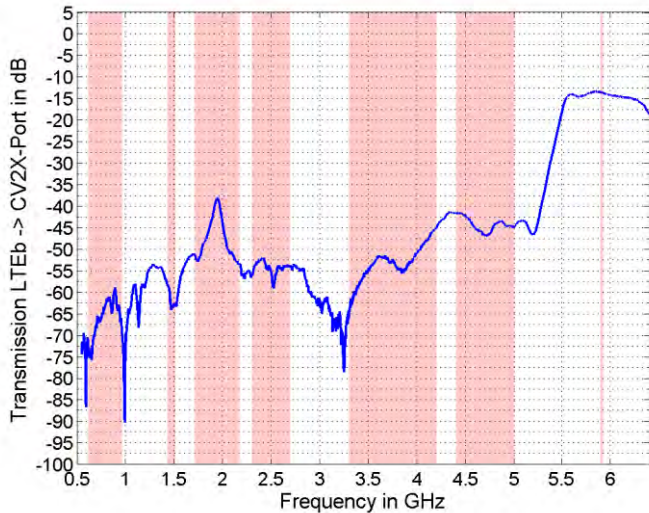
LTE back \Leftrightarrow BT



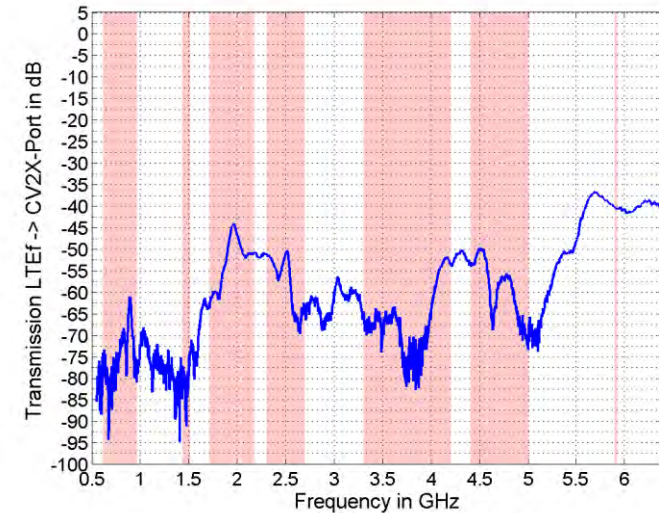
LTE front \Leftrightarrow BT



LTE back \Leftrightarrow C2C

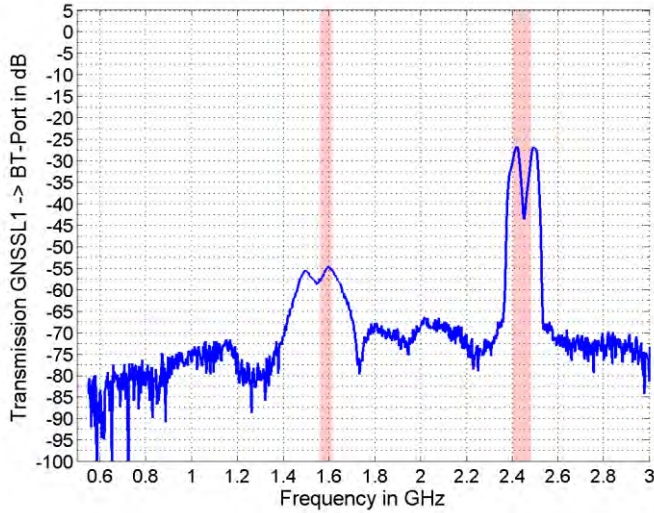


LTE front \Leftrightarrow C2C

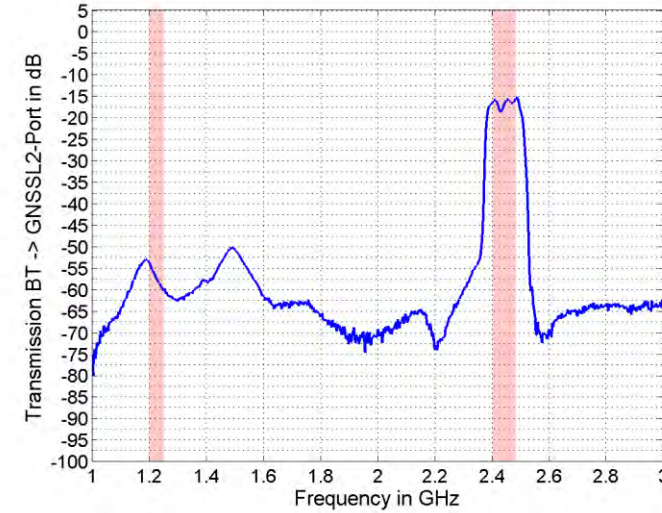


2.7 Variant E: Decoupling GNSS \leftrightarrow BT / CV2X

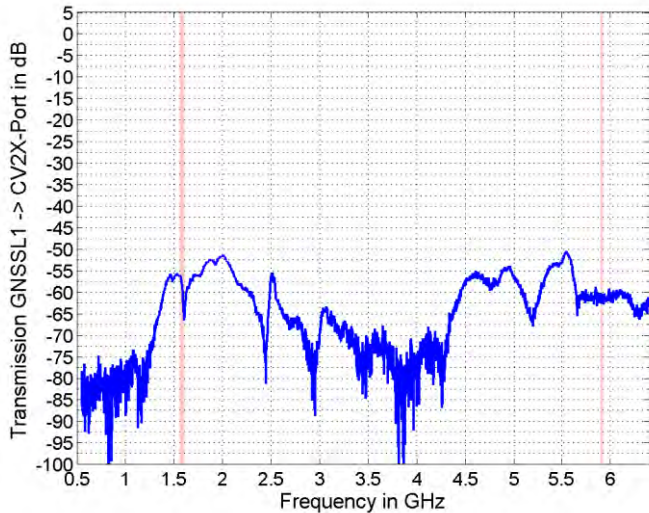
GNSS L1 \leftrightarrow BT



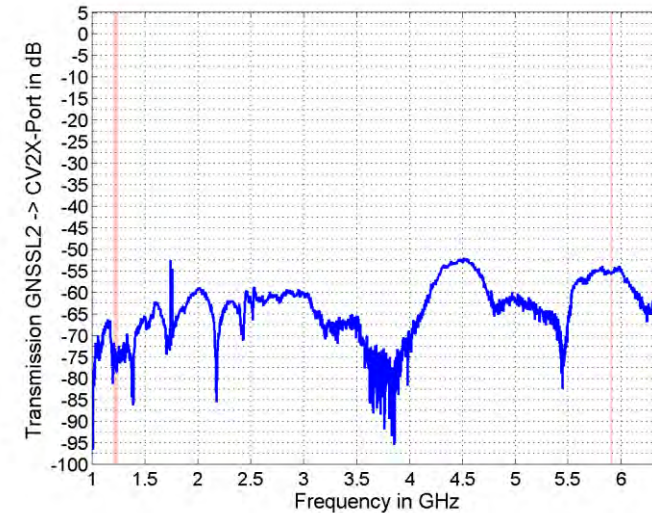
GNSS L2 \leftrightarrow BT



GNSS L1 \leftrightarrow C2C



GNSS L2 \leftrightarrow C2C



3. Data Variant A

2xLTE, 1xGNSS, BT

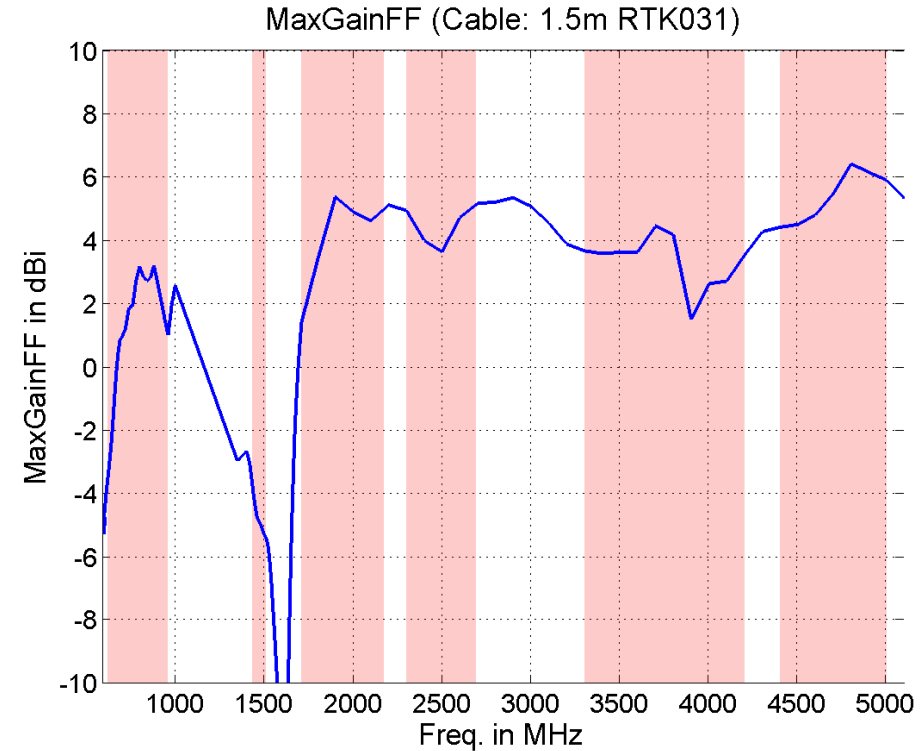
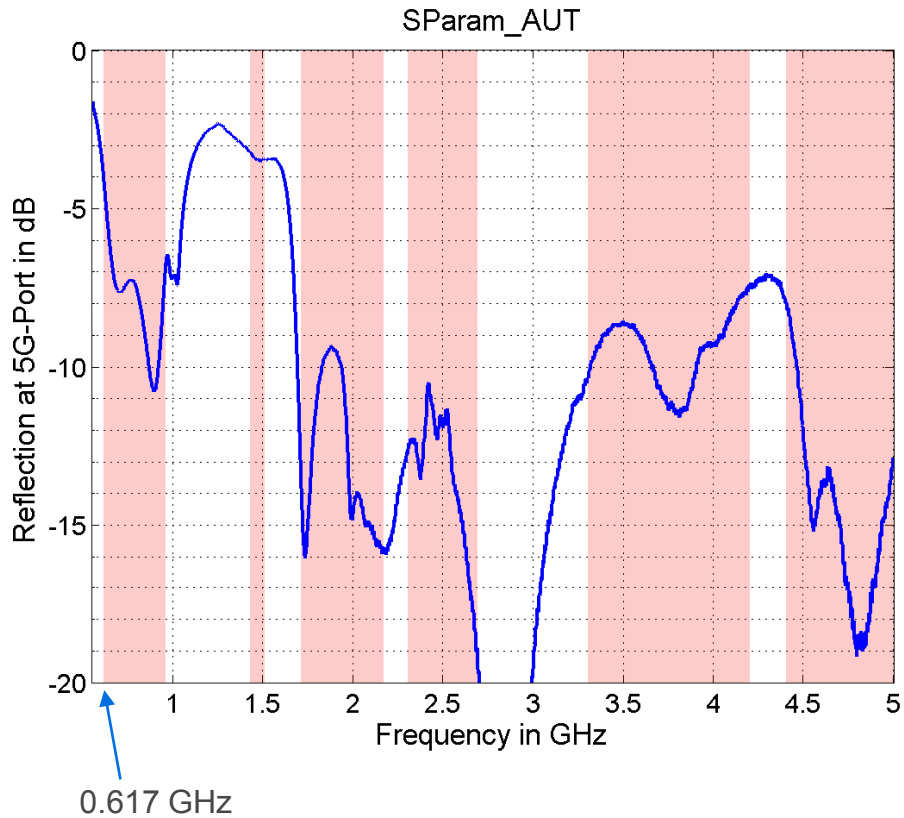


3.1 LTE Front (LTEf)



3.1 Variant A: LTE Antenna Performance Matching (LTE front)

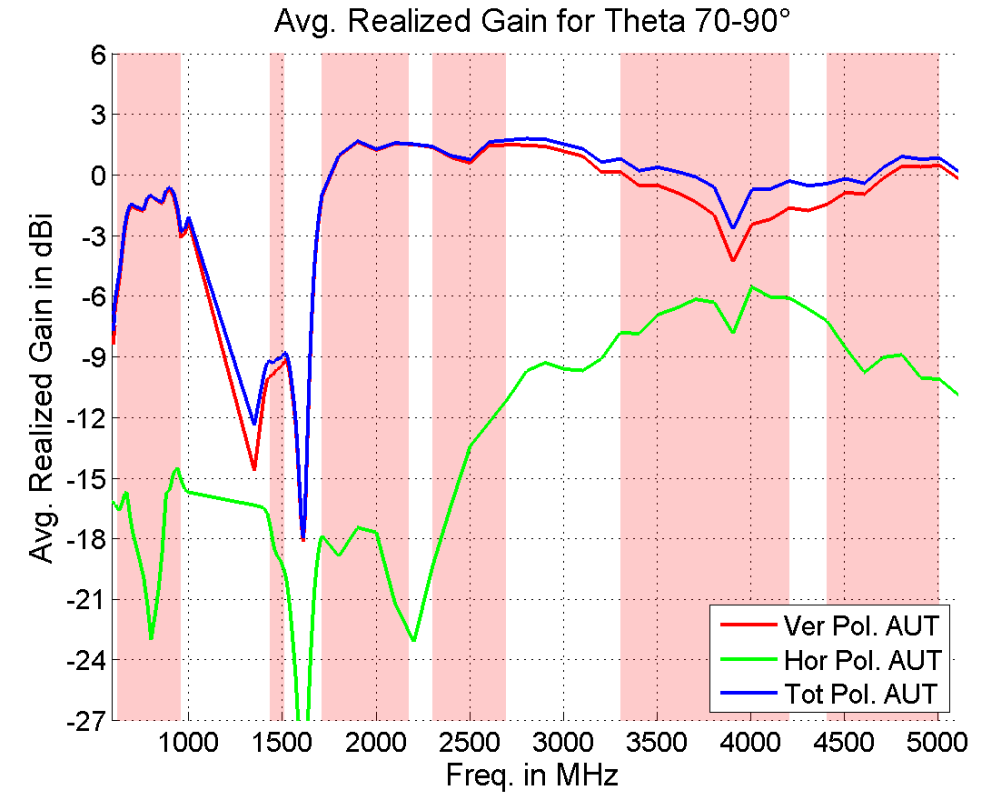
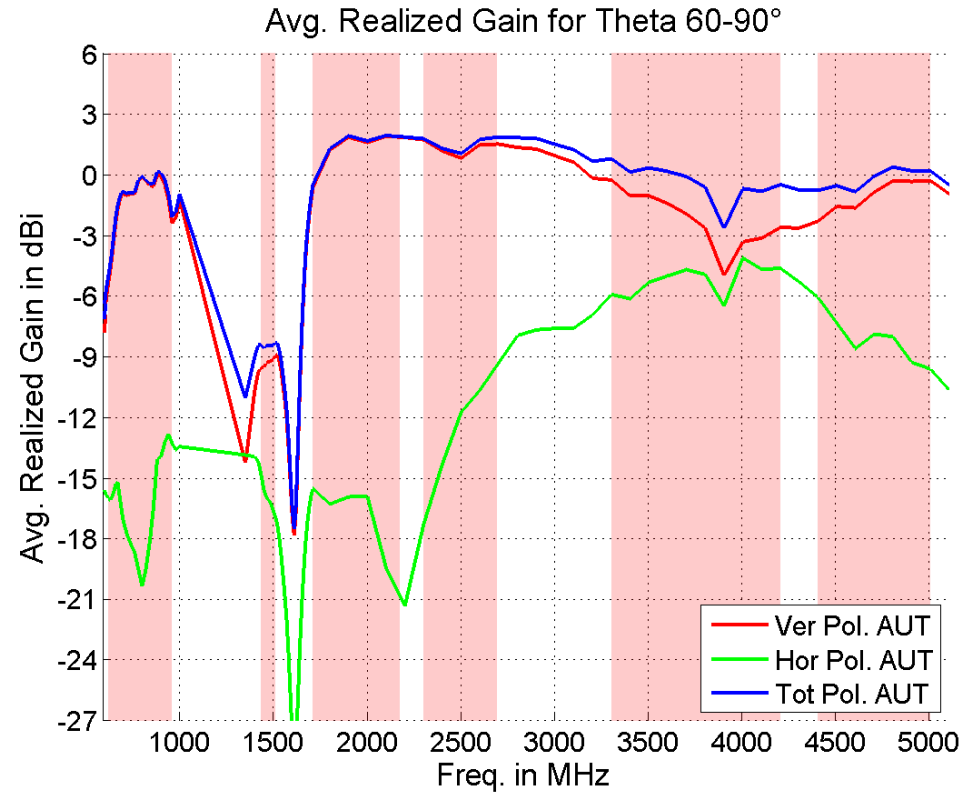
Chamber



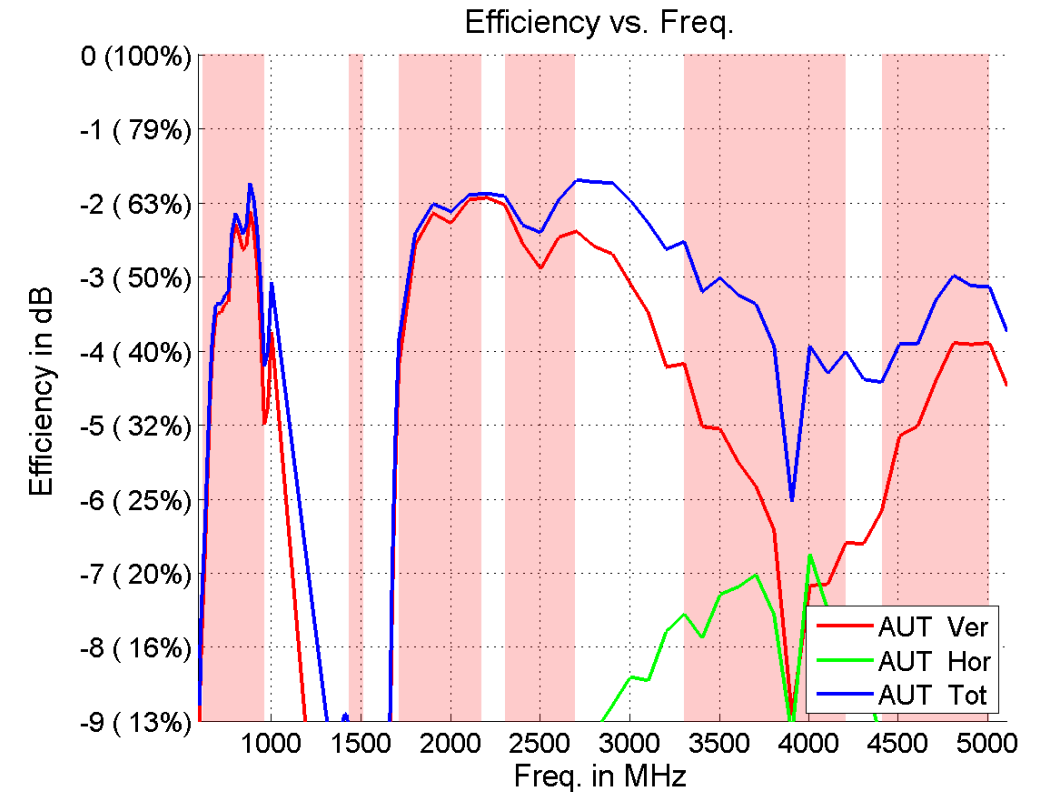
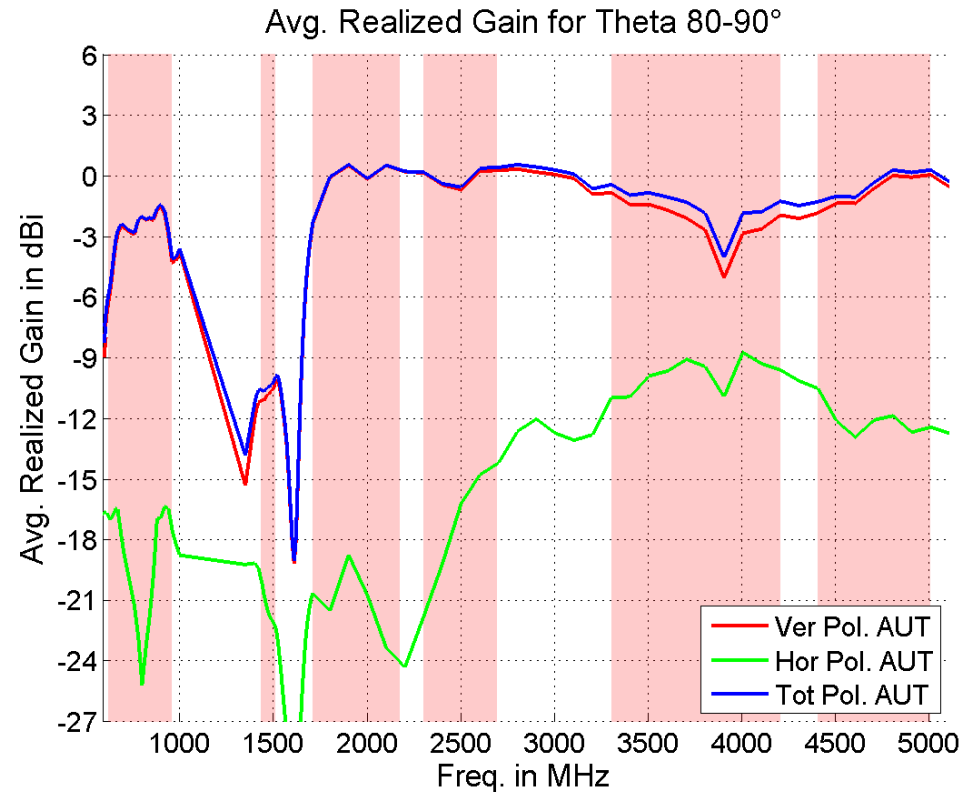
- The MaxGainFF-values are determined with 1.5m RTK031 cable (attenuation added to the measurement results).
- See attached file “Audi_CS_S11_VariantA_LTEf_gain_maxFF.csv” for the equivalent raw MaxGainFF-data.



3.1 Variant A: LTE Antenna Performance Gain and Efficiency (LTE front)

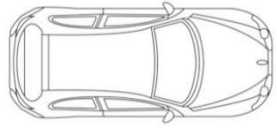


3.1 Variant A: LTE Antenna Performance Gain and Efficiency (LTE front)

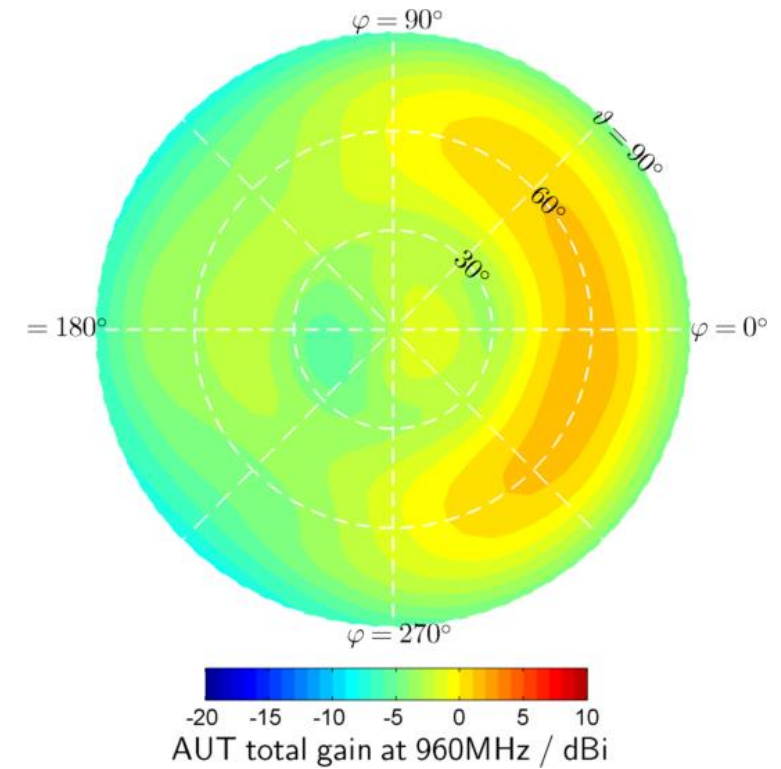
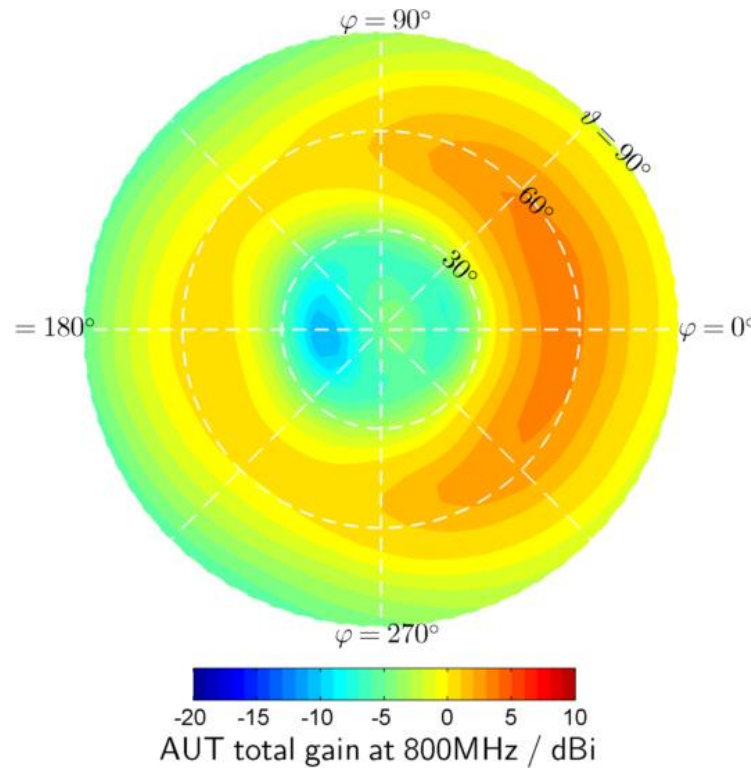
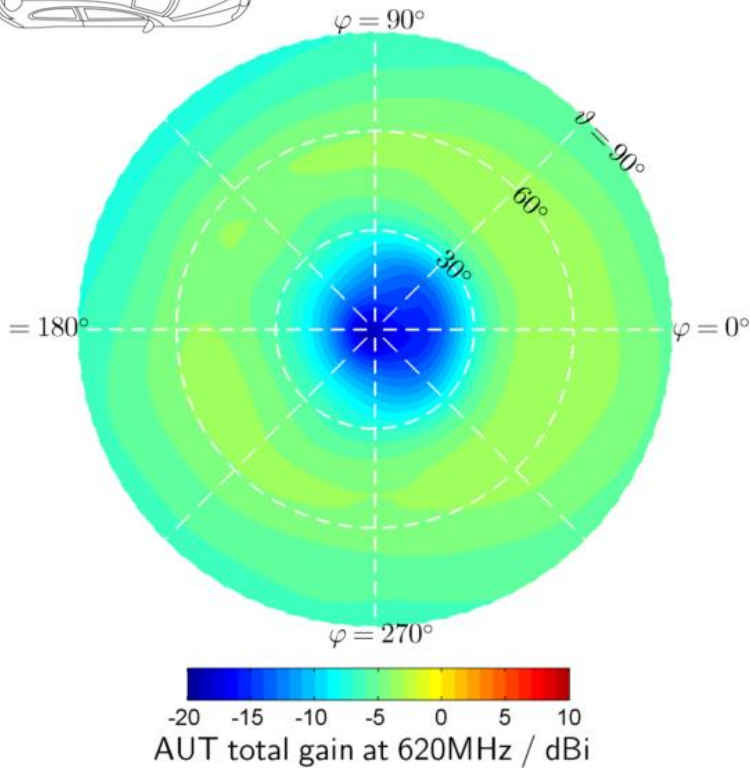


3.1 Variant A: LTE Antenna Performance 3D-Chart (LTE front)

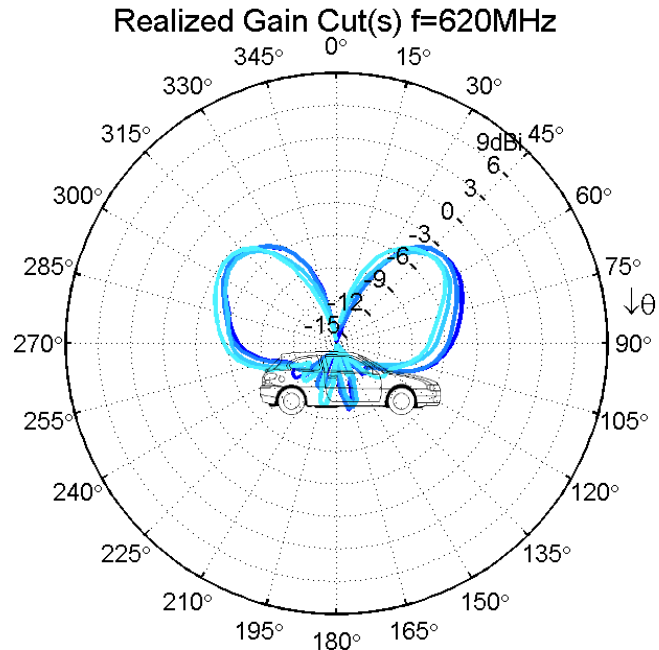
Chamber



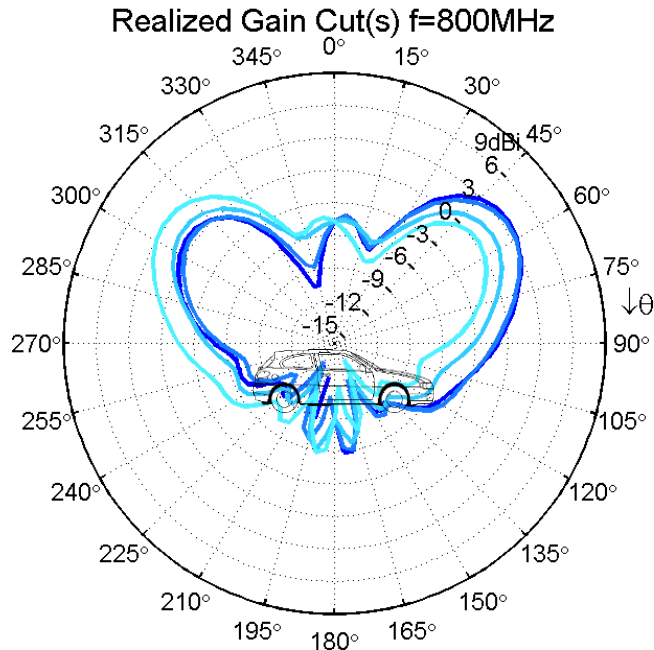
Driving Direction



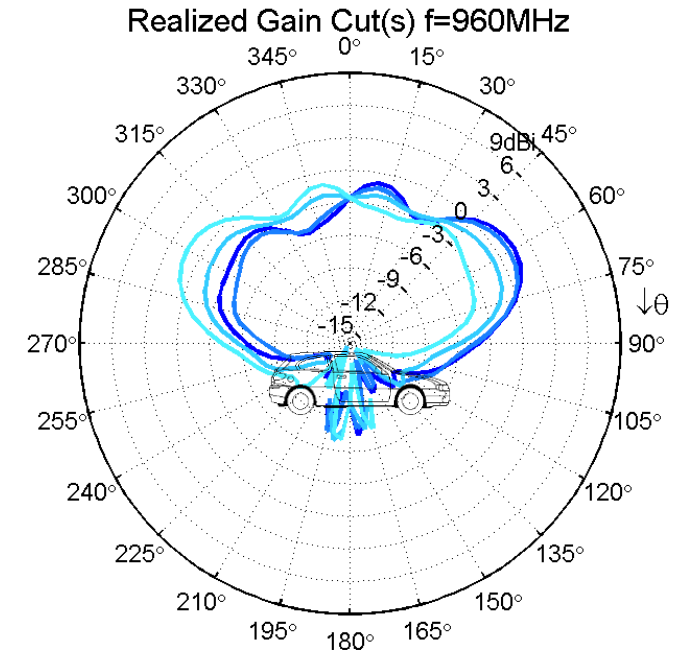
3.1 Variant A: LTE Antenna Performance Gain-Cuts (LTE front)



- AUT , $\phi=0^\circ$, Tot, Avg: -7.7dBi
- AUT , $\phi=45^\circ$, Tot, Avg: -7.7dBi
- AUT , $\phi=90^\circ$, Tot, Avg: -8.1dBi
- AUT , $\phi=135^\circ$, Tot, Avg: -7.9dBi



- AUT , $\phi=0^\circ$, Tot, Avg: -2.7dBi
- AUT , $\phi=45^\circ$, Tot, Avg: -2.9dBi
- AUT , $\phi=90^\circ$, Tot, Avg: -3.3dBi
- AUT , $\phi=135^\circ$, Tot, Avg: -3.0dBi

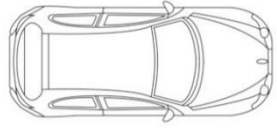


- AUT , $\phi=0^\circ$, Tot, Avg: -4.3dBi
- AUT , $\phi=45^\circ$, Tot, Avg: -4.6dBi
- AUT , $\phi=90^\circ$, Tot, Avg: -4.5dBi
- AUT , $\phi=135^\circ$, Tot, Avg: -4.3dBi

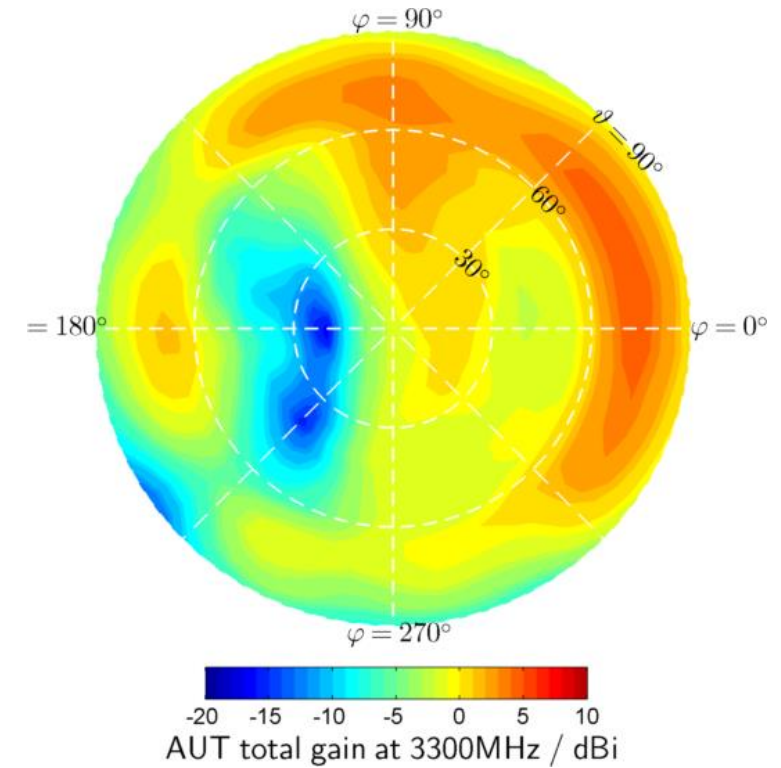
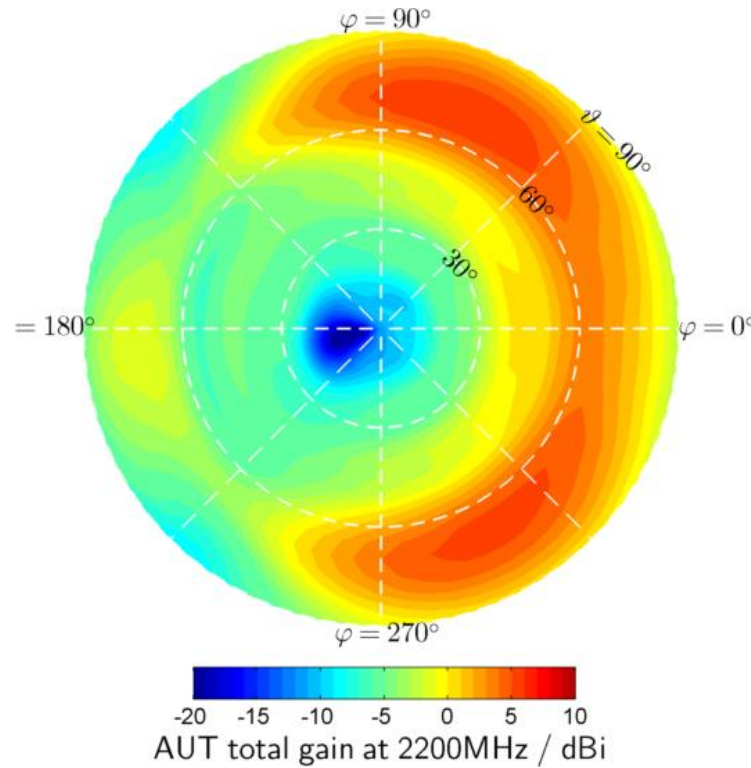
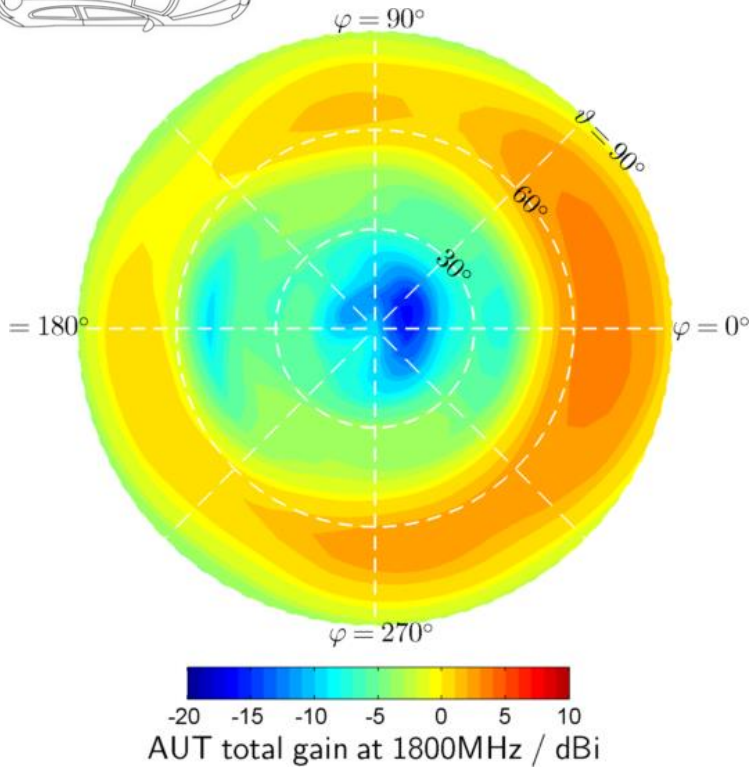


3.1 Variant A: LTE Antenna Performance 3D-Chart (LTE front)

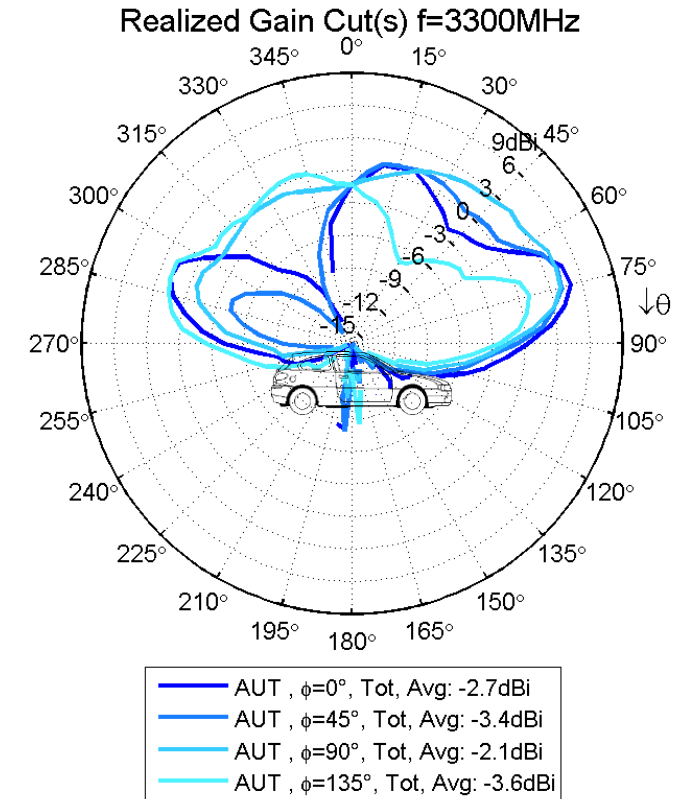
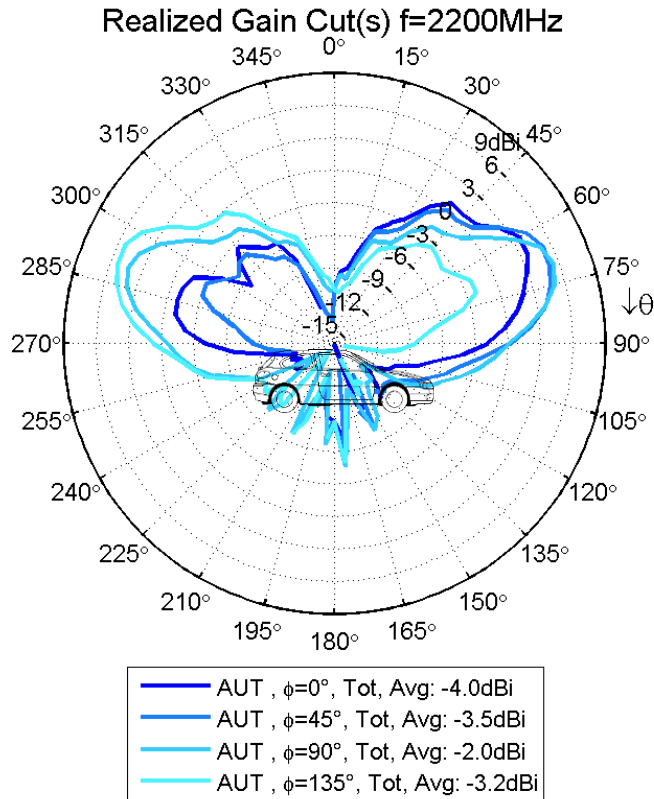
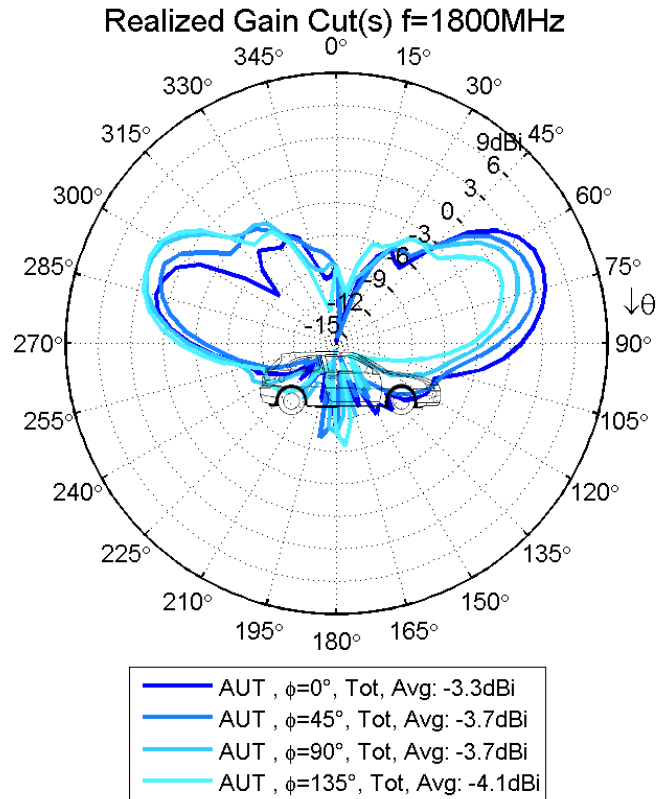
Chamber



Driving Direction

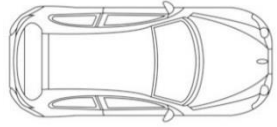


3.1 Variant A: LTE Antenna Performance Gain-Cuts (LTE front)

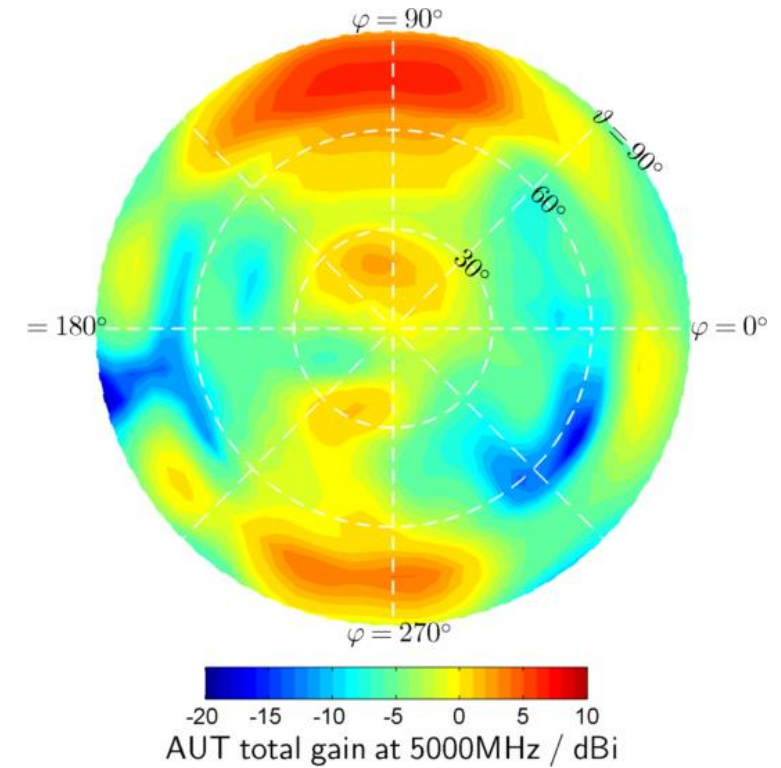
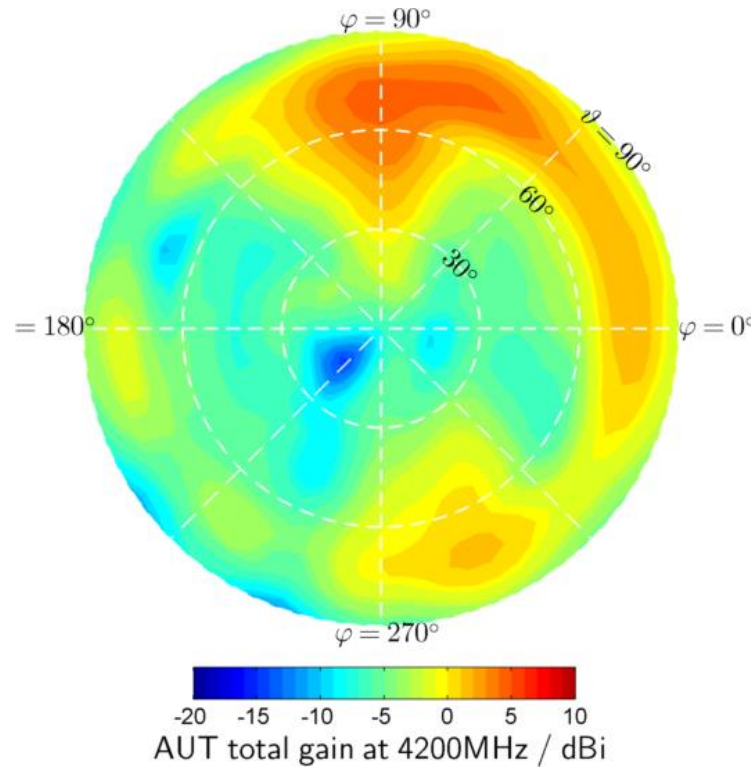
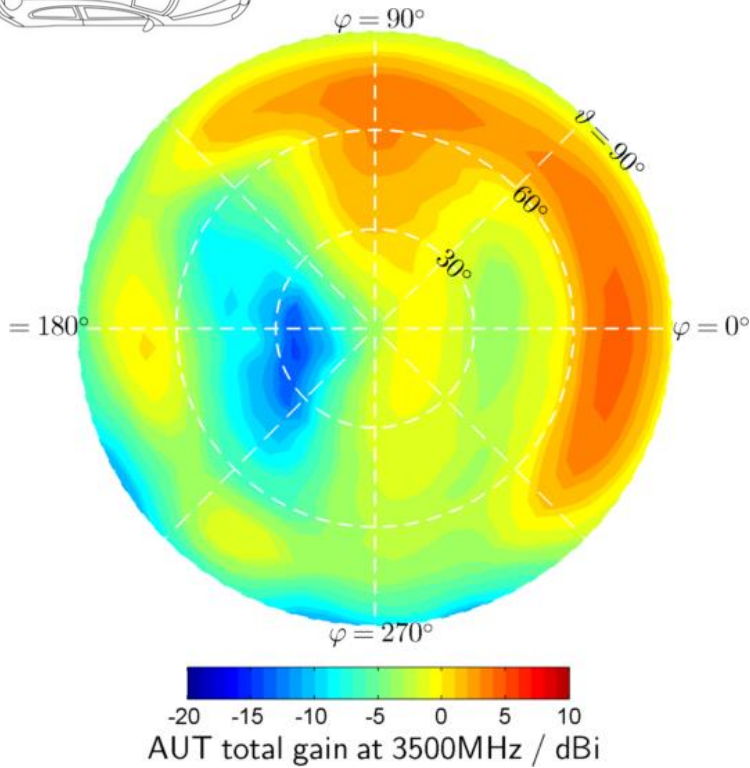


3.1 Variant A: LTE Antenna Performance 3D-Chart (LTE front)

Chamber

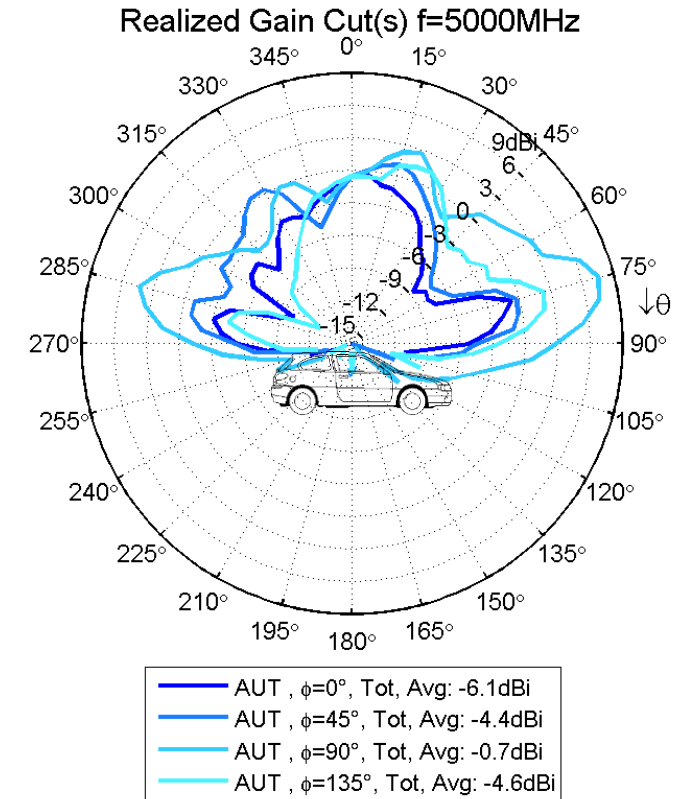
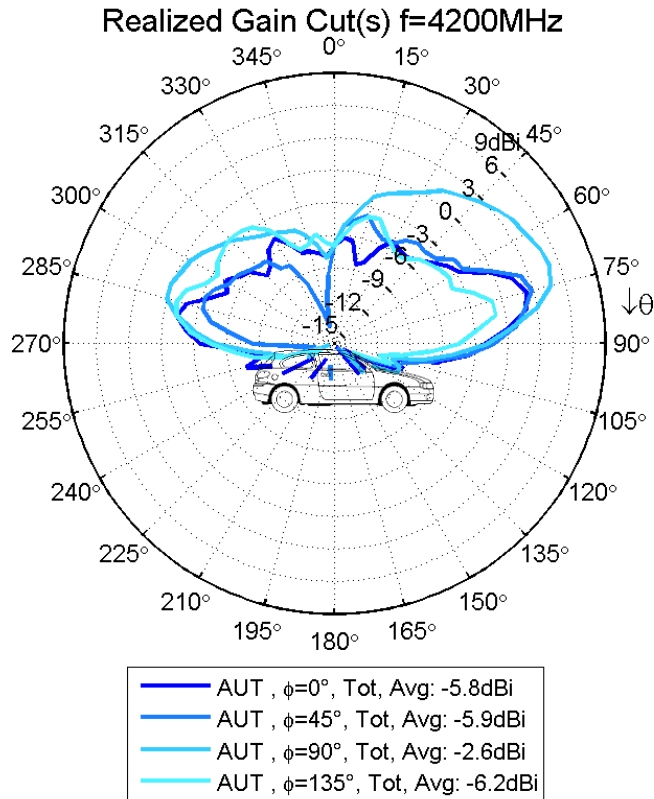
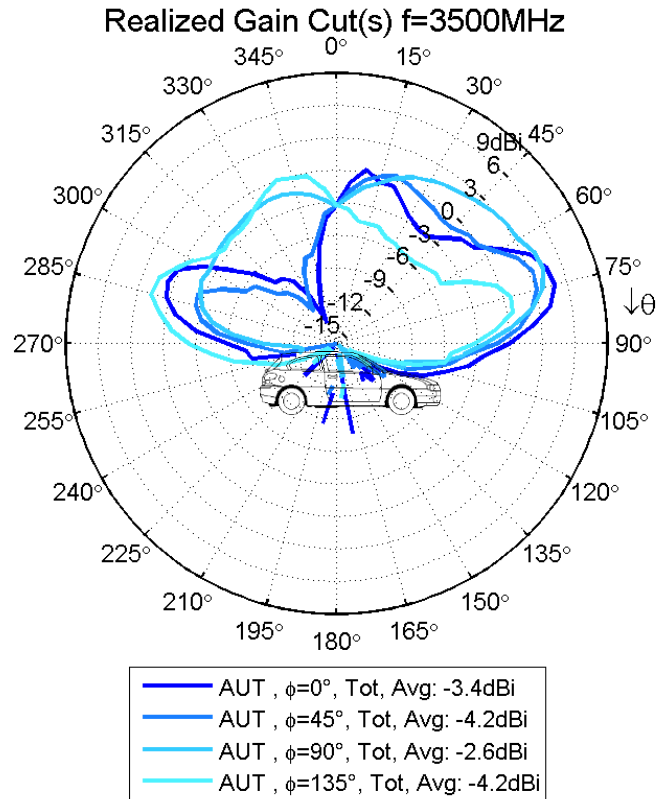


Driving Direction



3.1 Variant A: LTE Antenna Performance Gain-Cuts (LTE front)

Chamber

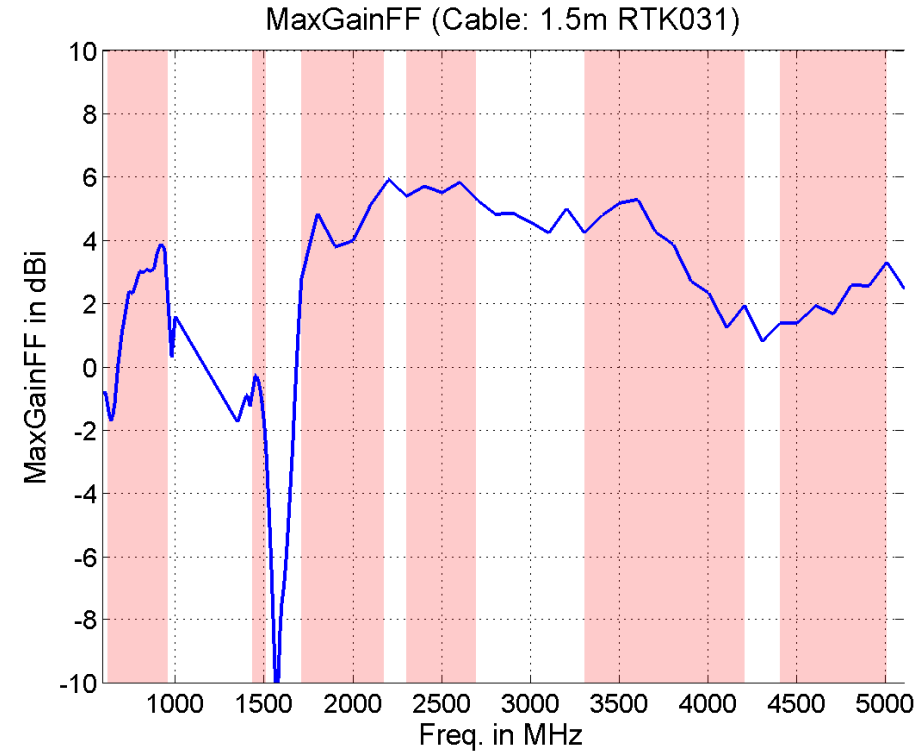
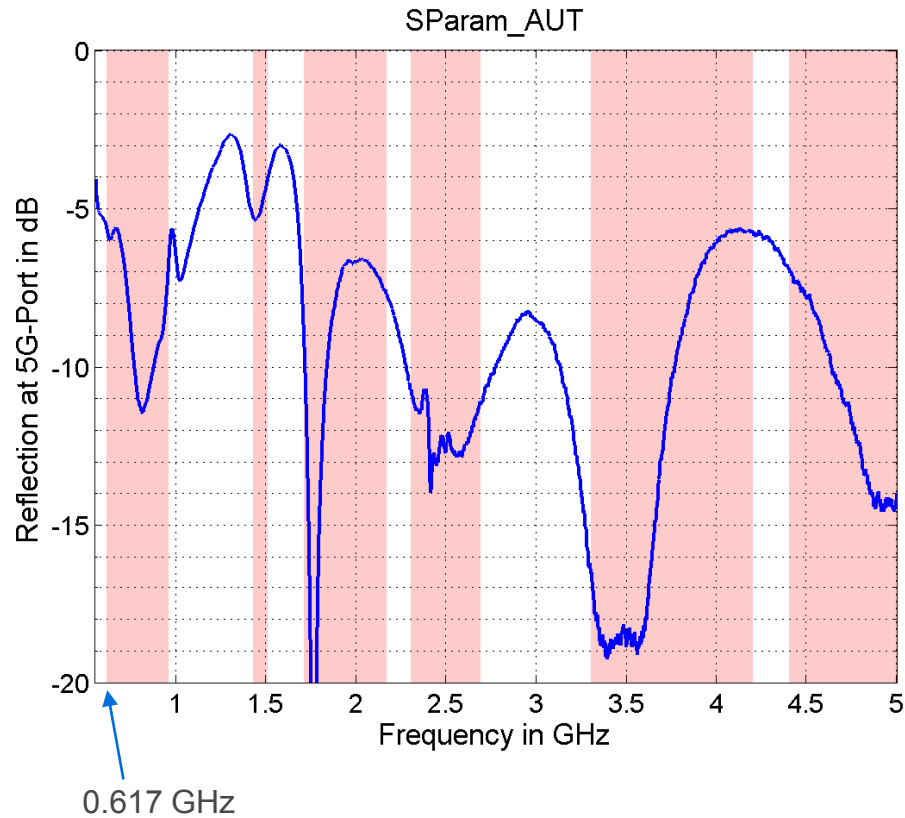


3.2 LTE Back (LTEb)



3.2 Variant A: LTE Antenna Performance Matching (LTE back)

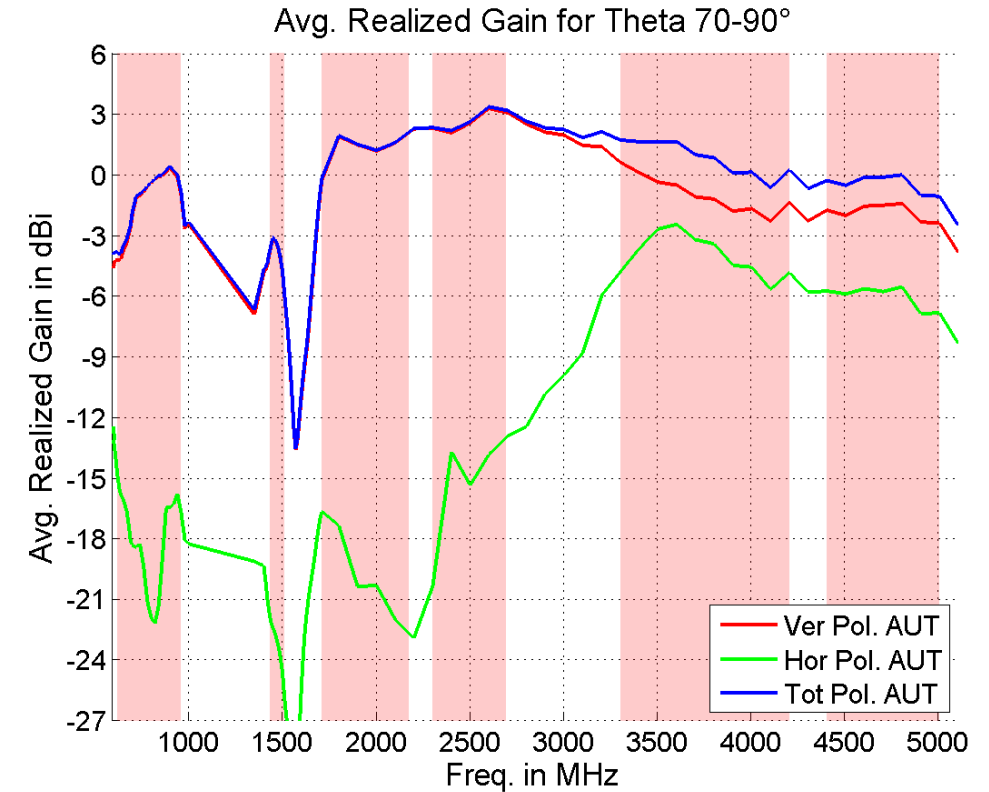
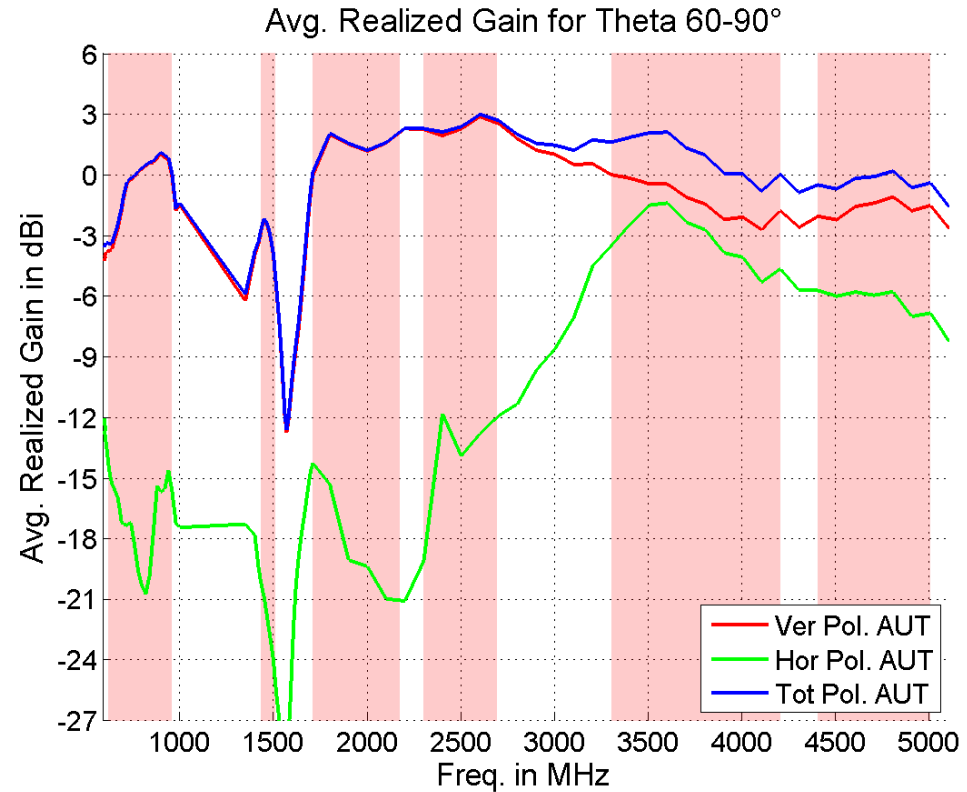
Chamber



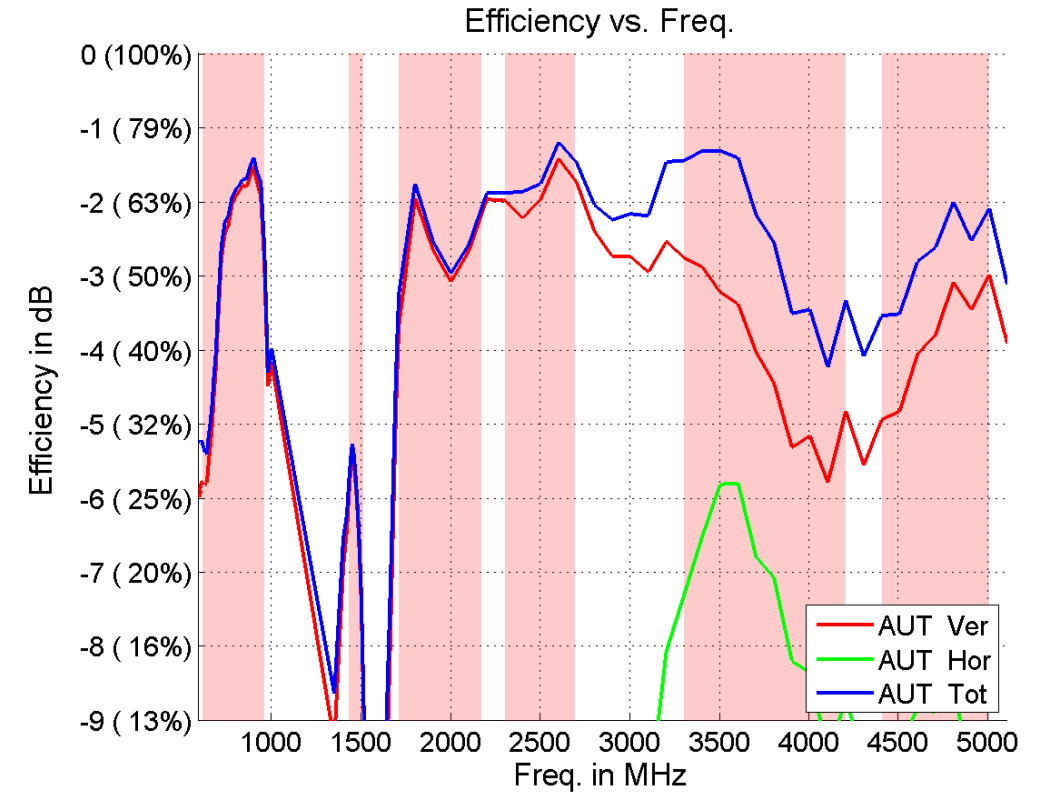
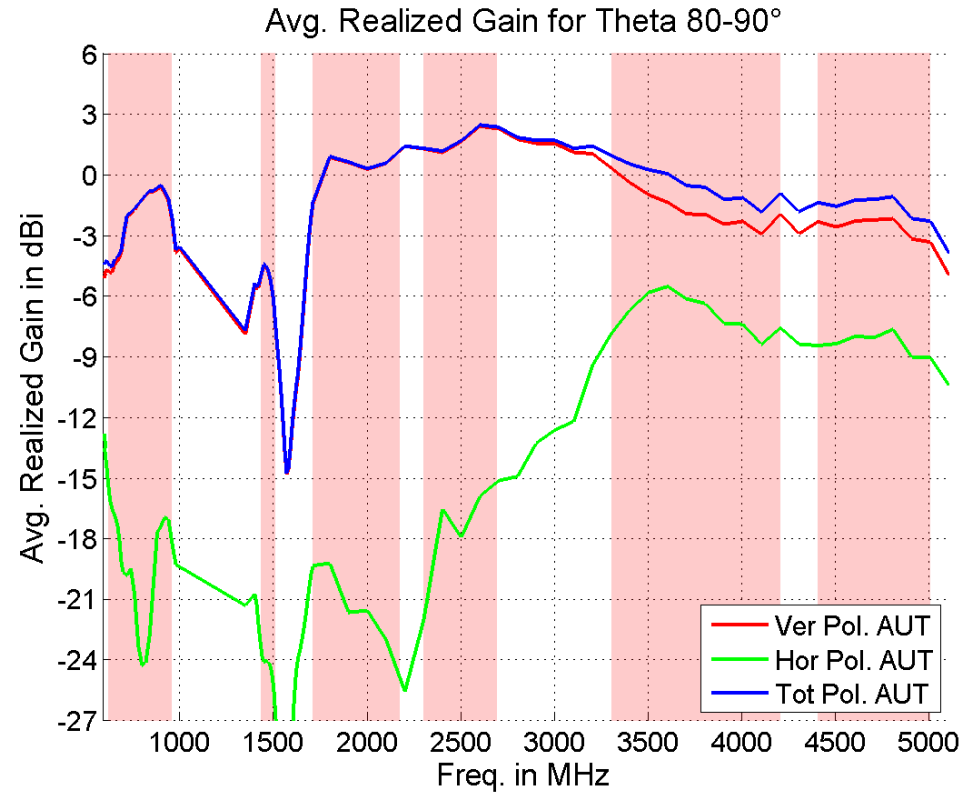
- The MaxGainFF-values are determined with 1.5m RTK031 cable (attenuation added to the measurement results).
- See attached file “Audi_CS_S11_VariantA_LTEb_gain_maxFF.csv” for the equivalent raw MaxGainFF-data.



3.2 Variant A: LTE Antenna Performance Gain and Efficiency (LTE back)

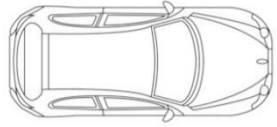


3.2 Variant A: LTE Antenna Performance Gain and Efficiency (LTE back)

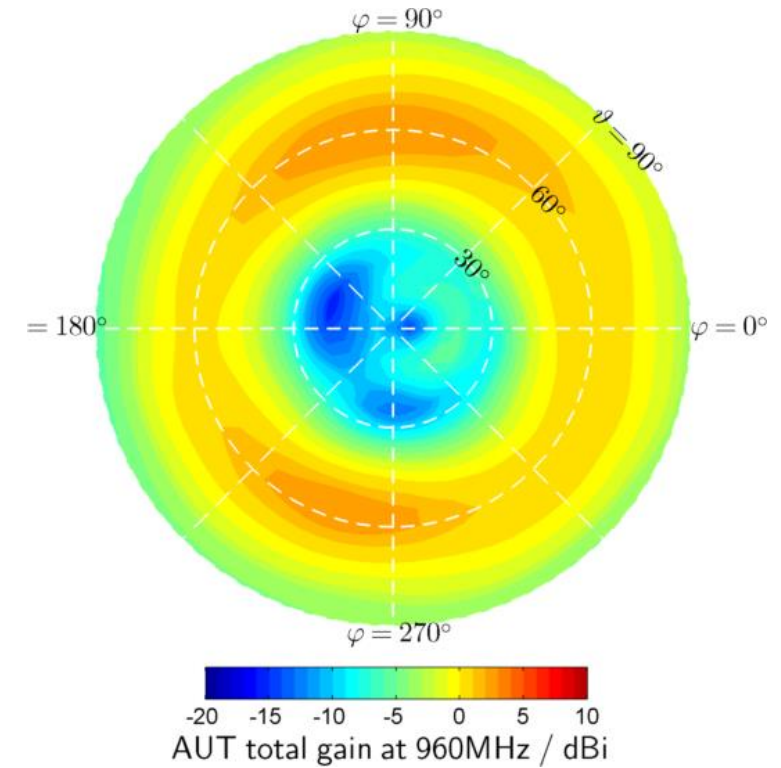
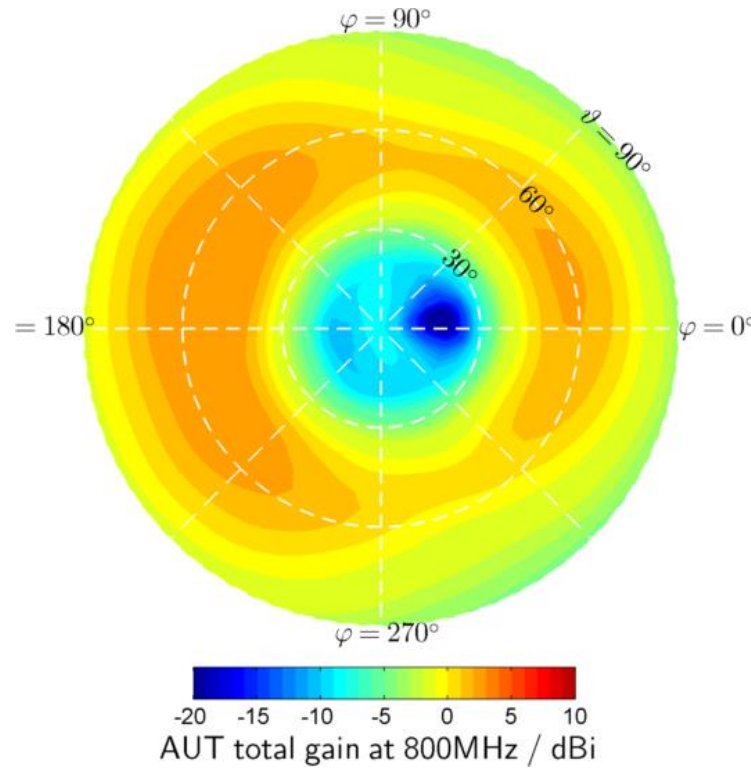
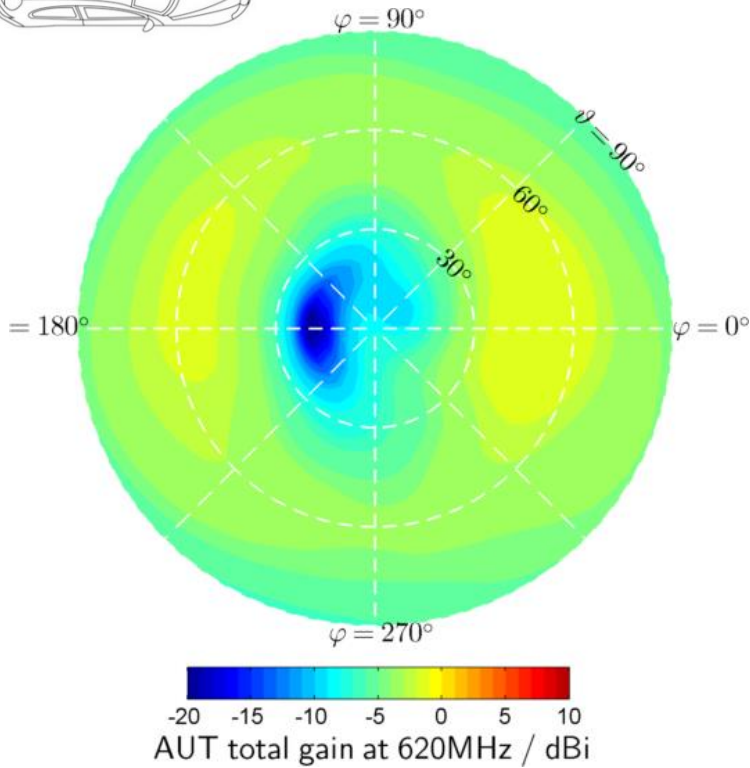


3.2 Variant A: LTE Antenna Performance 3D-Chart (LTE back)

Chamber

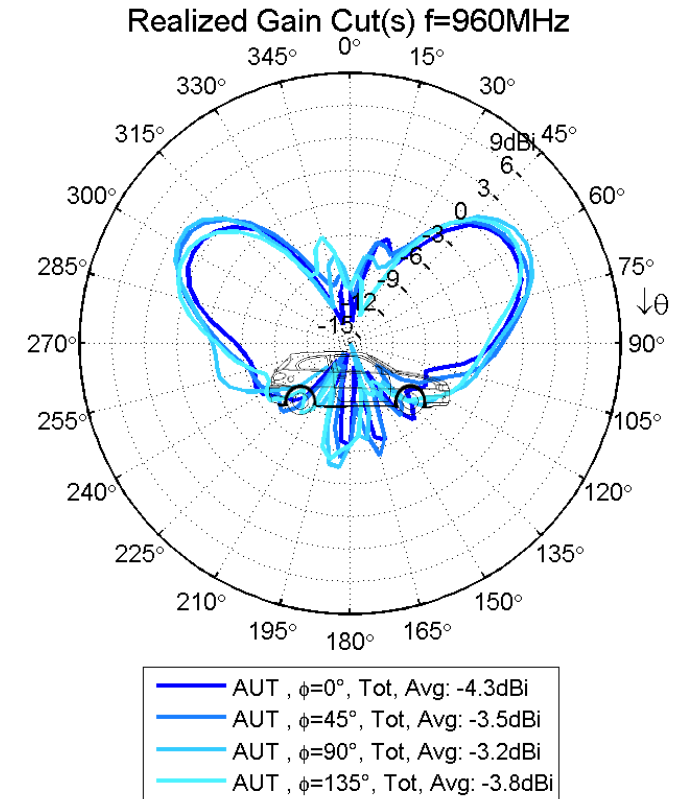
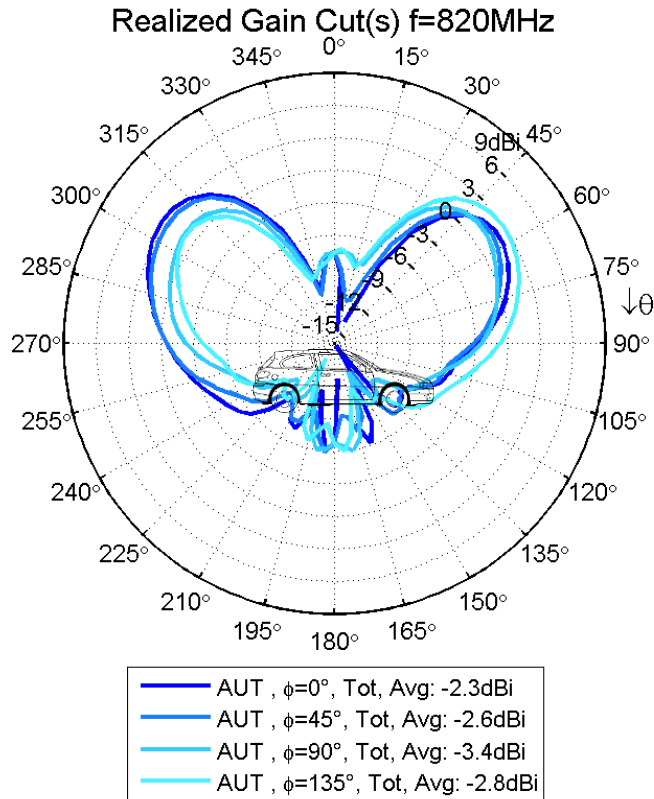
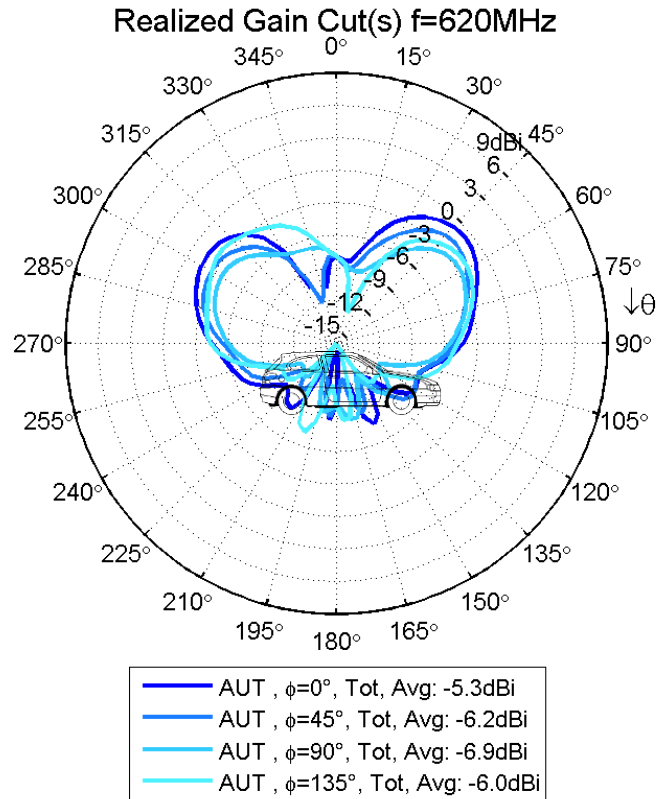


Driving Direction



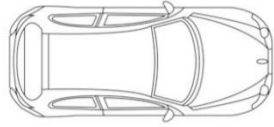
3.2 Variant A: LTE Antenna Performance Gain-Cuts (LTE back)

Chamber

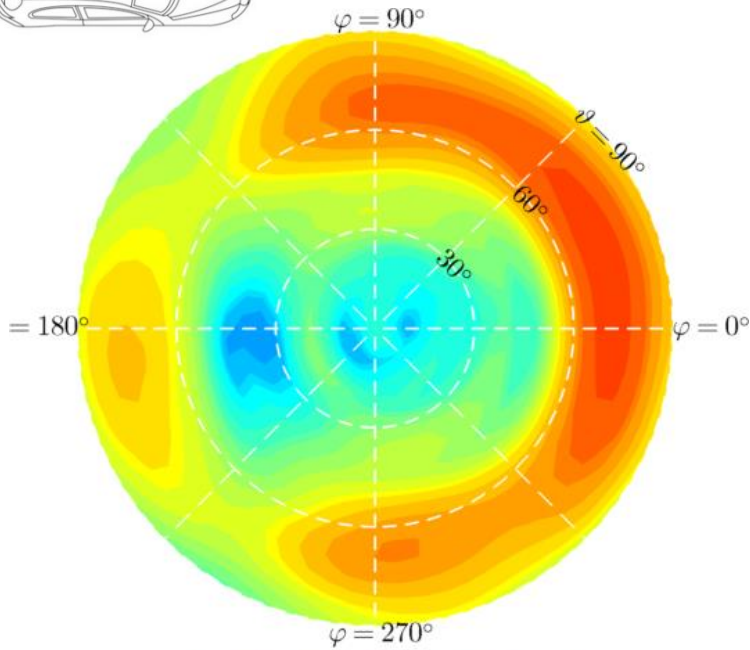


3.2 Variant A: LTE Antenna Performance 3D-Chart (LTE back)

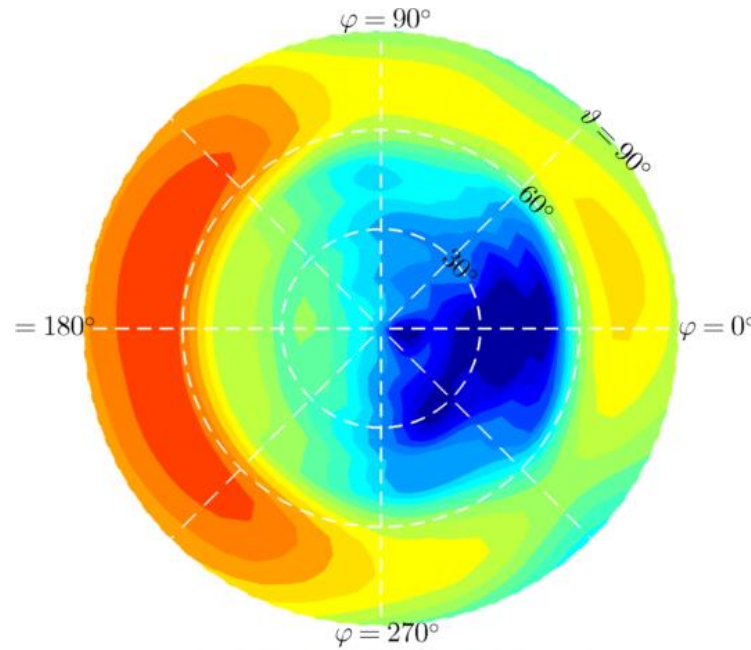
Chamber



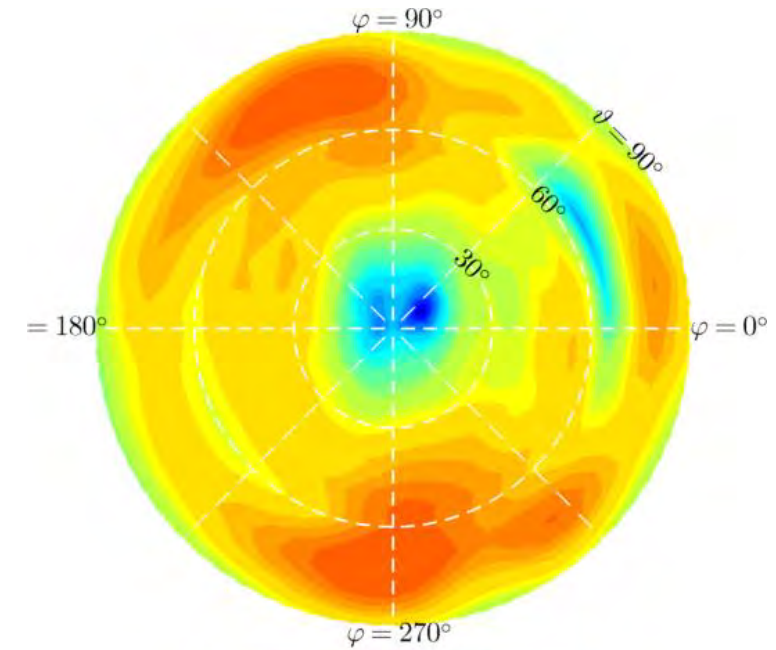
Driving Direction



AUT total gain at 1800MHz / dBi



AUT total gain at 2200MHz / dBi

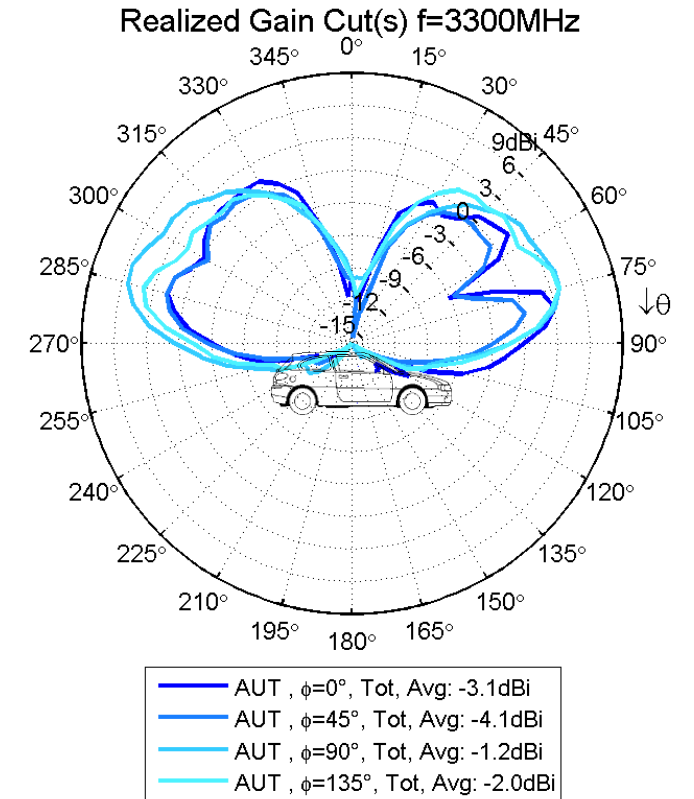
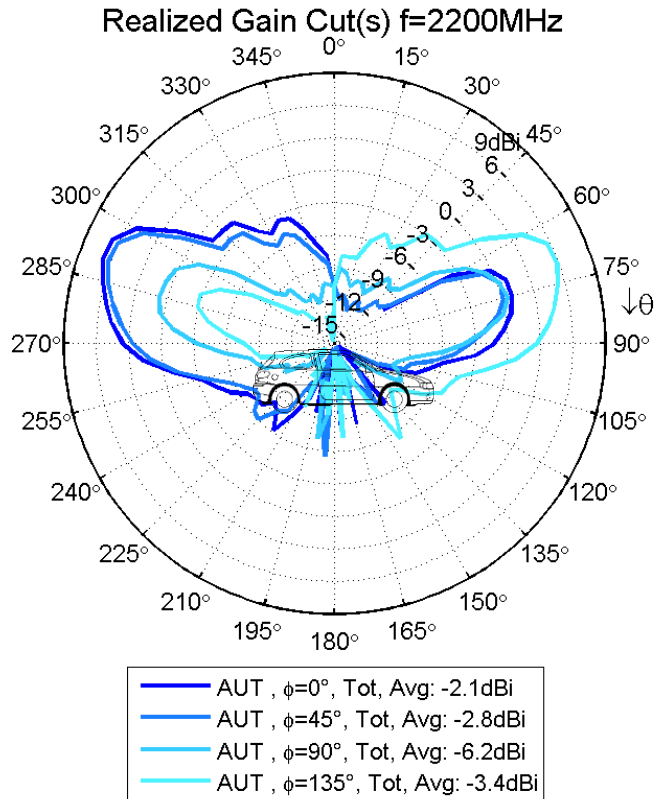
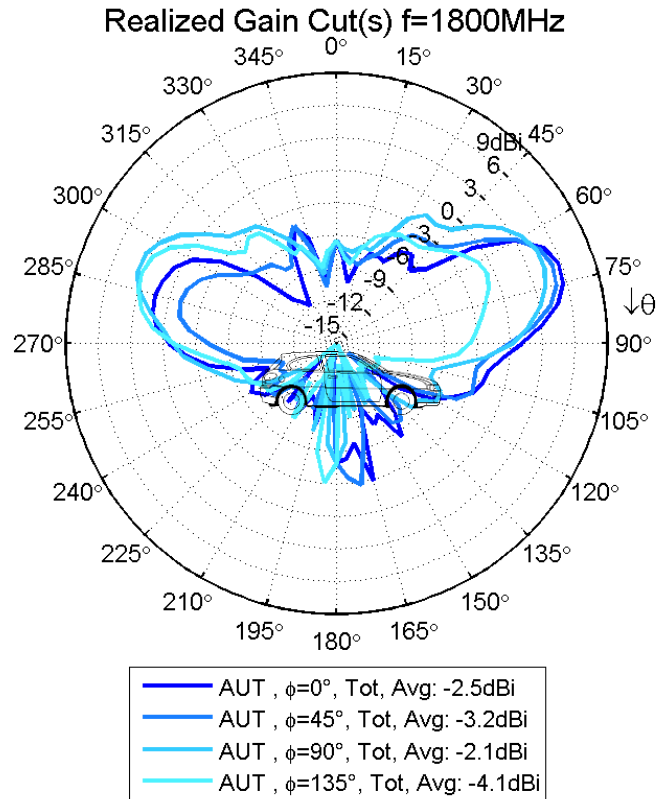


AUT total gain at 3300MHz / dBi



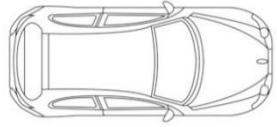
3.2 Variant A: LTE Antenna Performance Gain-Cuts (LTE back)

Chamber

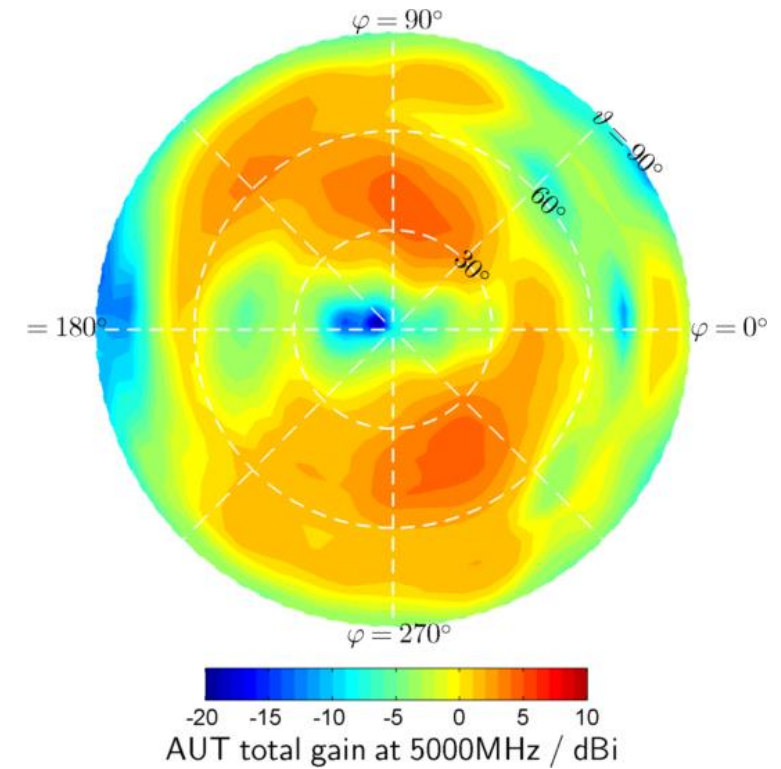
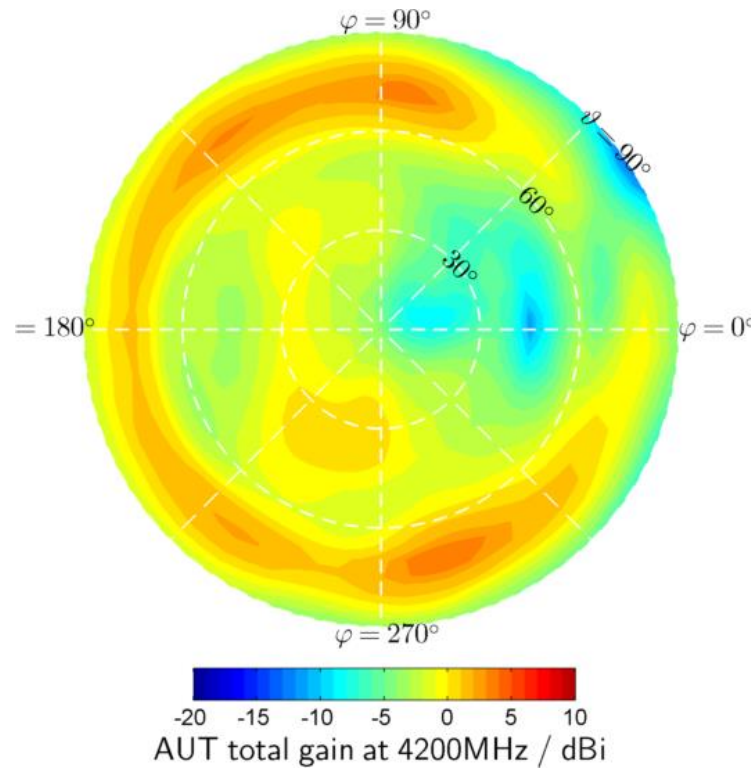
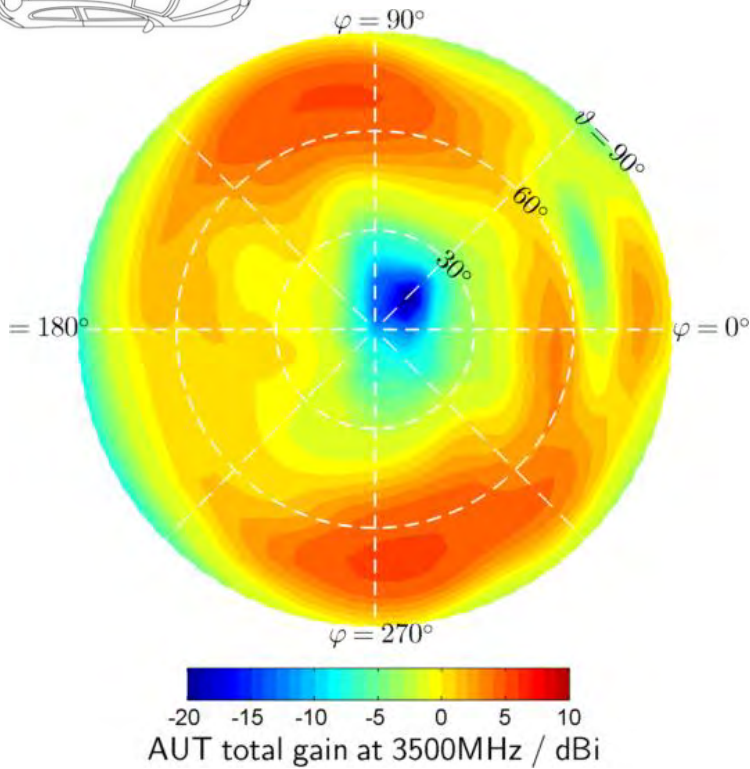


3.2 Variant A: LTE Antenna Performance 3D-Chart (LTE back)

Chamber

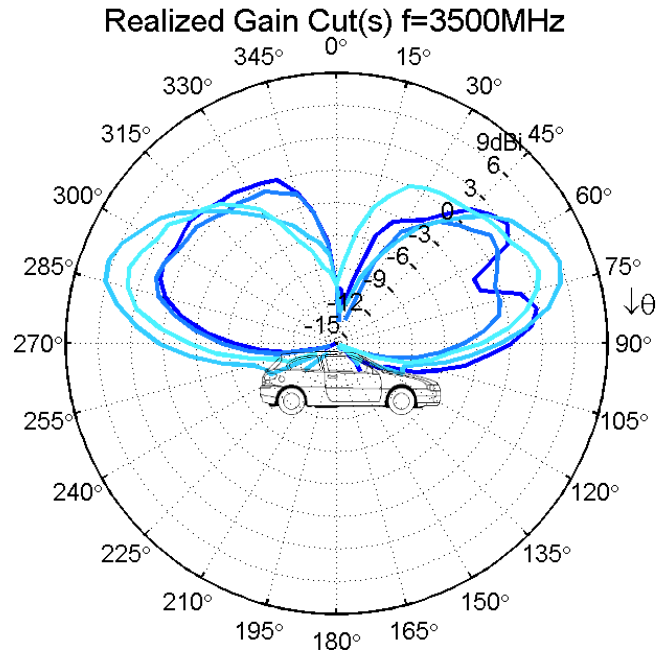


Driving Direction

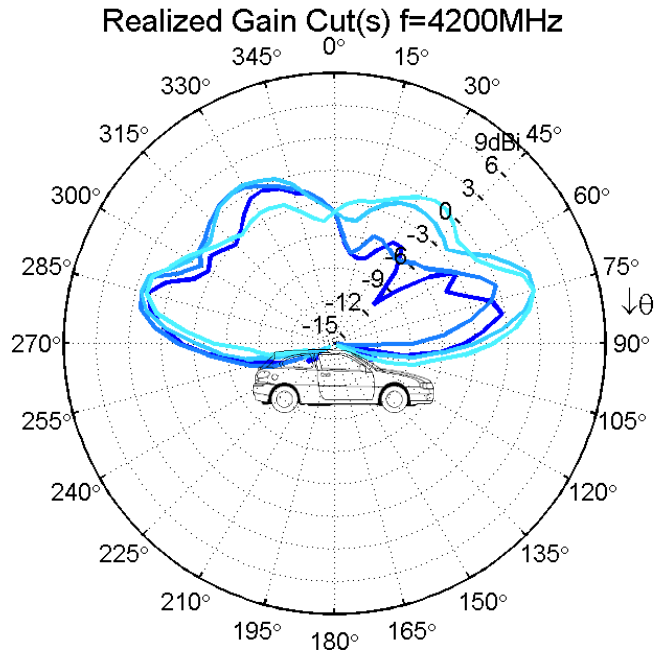


3.2 Variant A: LTE Antenna Performance Gain-Cuts (LTE back)

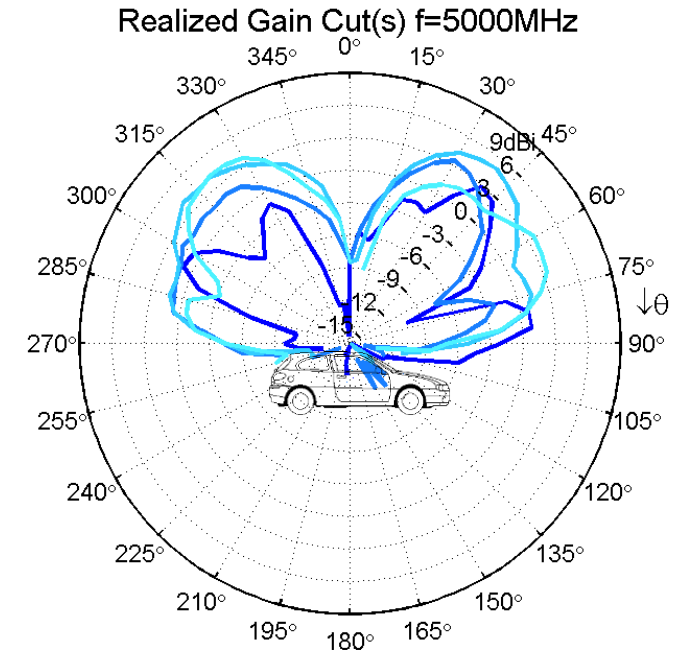
Chamber



- AUT , $\phi=0^\circ$, Tot, Avg: -3.0dBi
- AUT , $\phi=45^\circ$, Tot, Avg: -4.1dBi
- AUT , $\phi=90^\circ$, Tot, Avg: -1.0dBi
- AUT , $\phi=135^\circ$, Tot, Avg: -2.0dBi



- AUT , $\phi=0^\circ$, Tot, Avg: -5.1dBi
- AUT , $\phi=45^\circ$, Tot, Avg: -4.3dBi
- AUT , $\phi=90^\circ$, Tot, Avg: -3.1dBi
- AUT , $\phi=135^\circ$, Tot, Avg: -3.4dBi



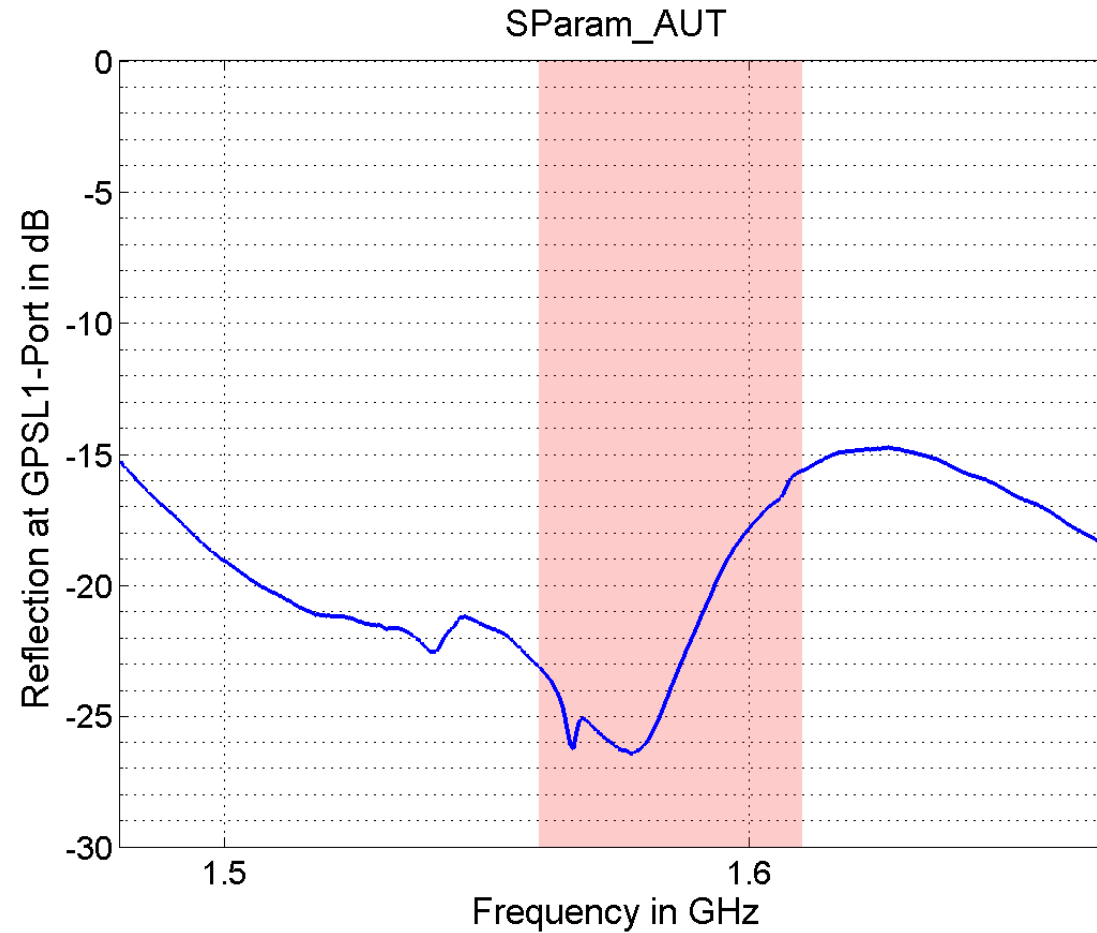
- AUT , $\phi=0^\circ$, Tot, Avg: -4.8dBi
- AUT , $\phi=45^\circ$, Tot, Avg: -3.1dBi
- AUT , $\phi=90^\circ$, Tot, Avg: -1.1dBi
- AUT , $\phi=135^\circ$, Tot, Avg: -2.0dBi



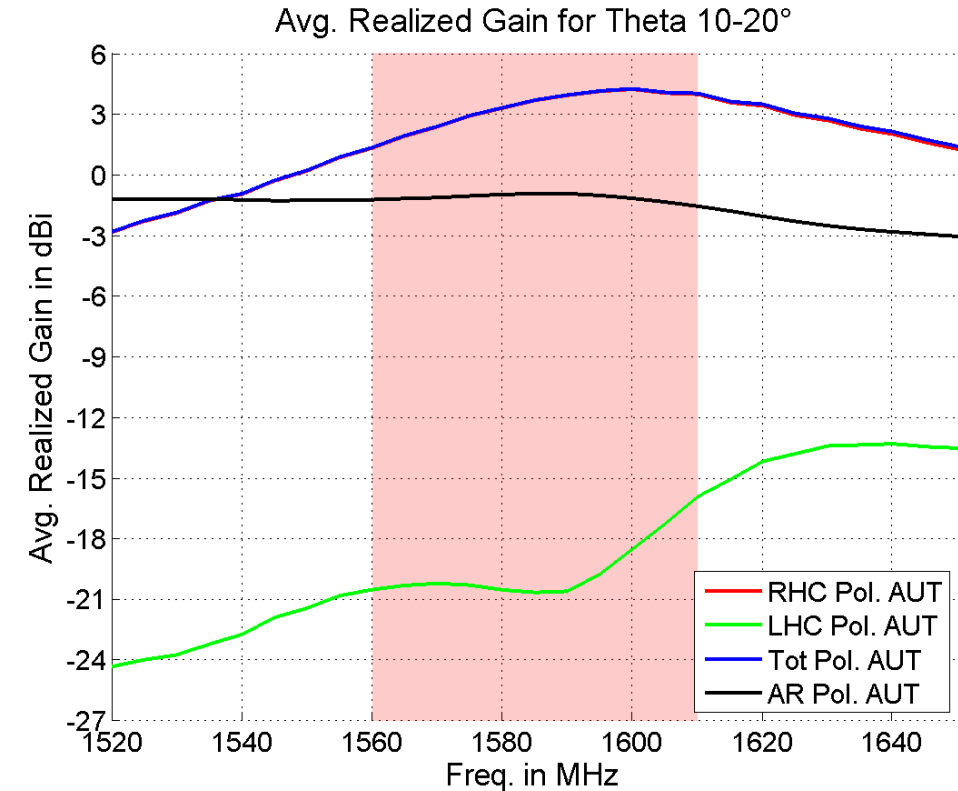
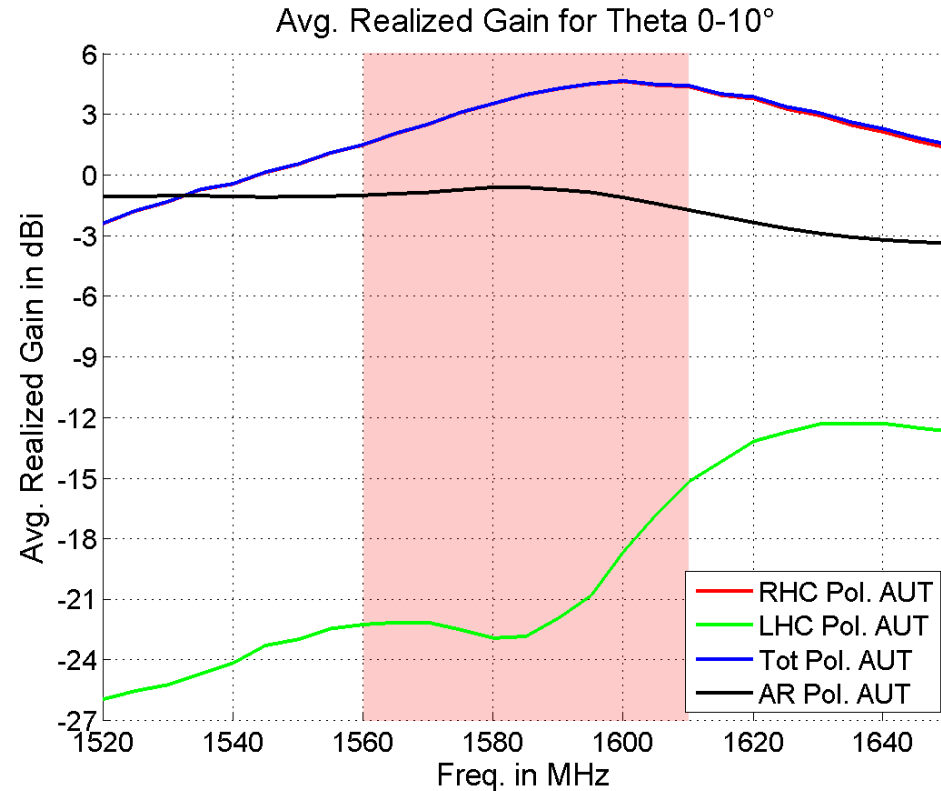
3.3 GNSS L1



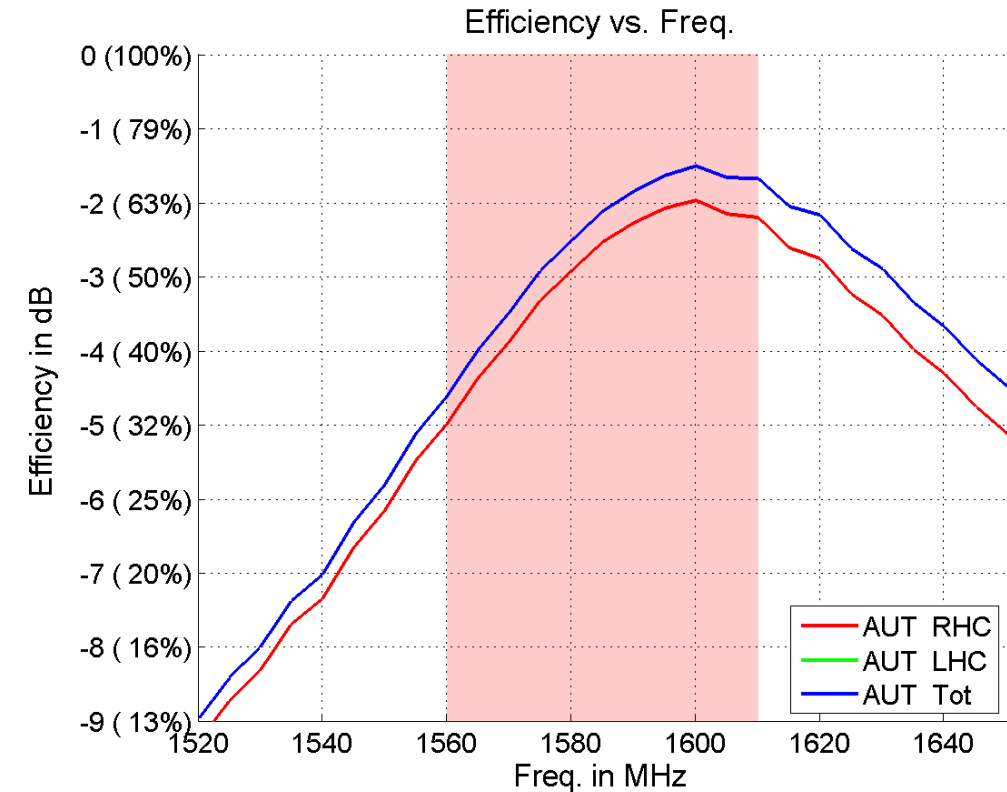
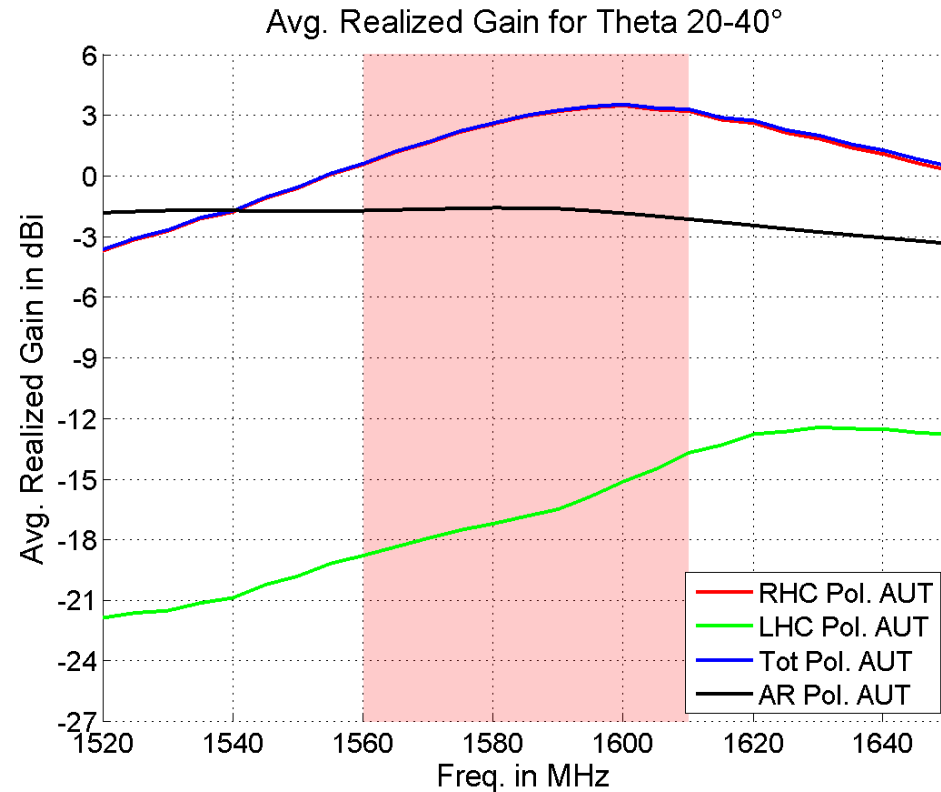
3.3 Variant A: Satellite Antenna Performance Matching (GNSS L1)



3.3 Variant A: Satellite Antenna Performance Gain and Efficiency (GNSS L1)

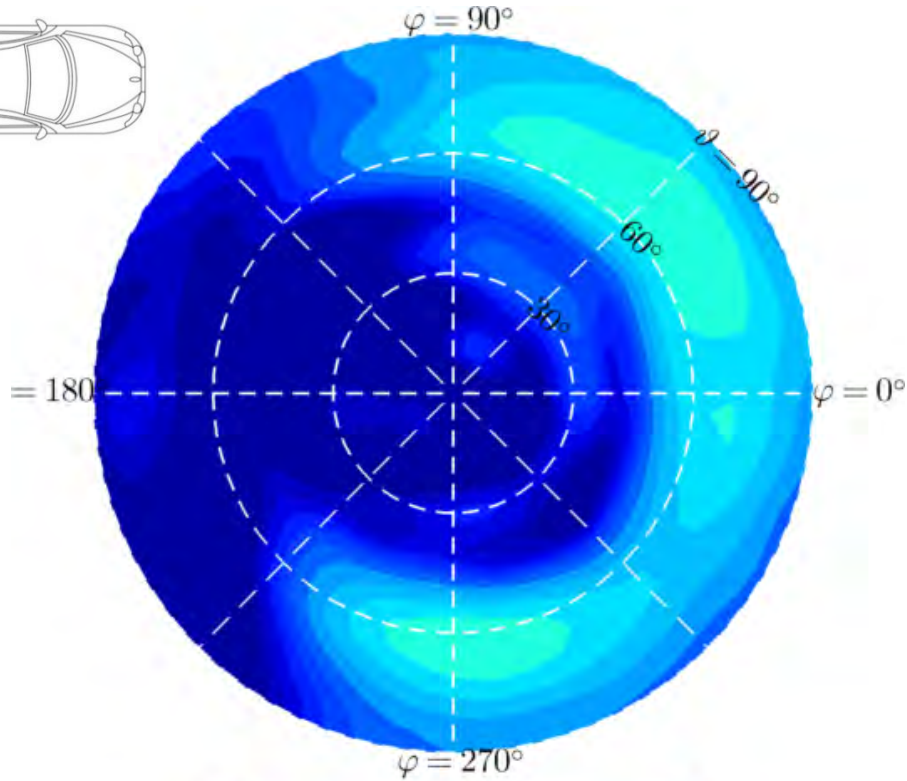
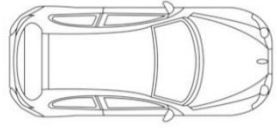


3.3 Variant A: Satellite Antenna Performance Gain and Efficiency (GNSS L1)

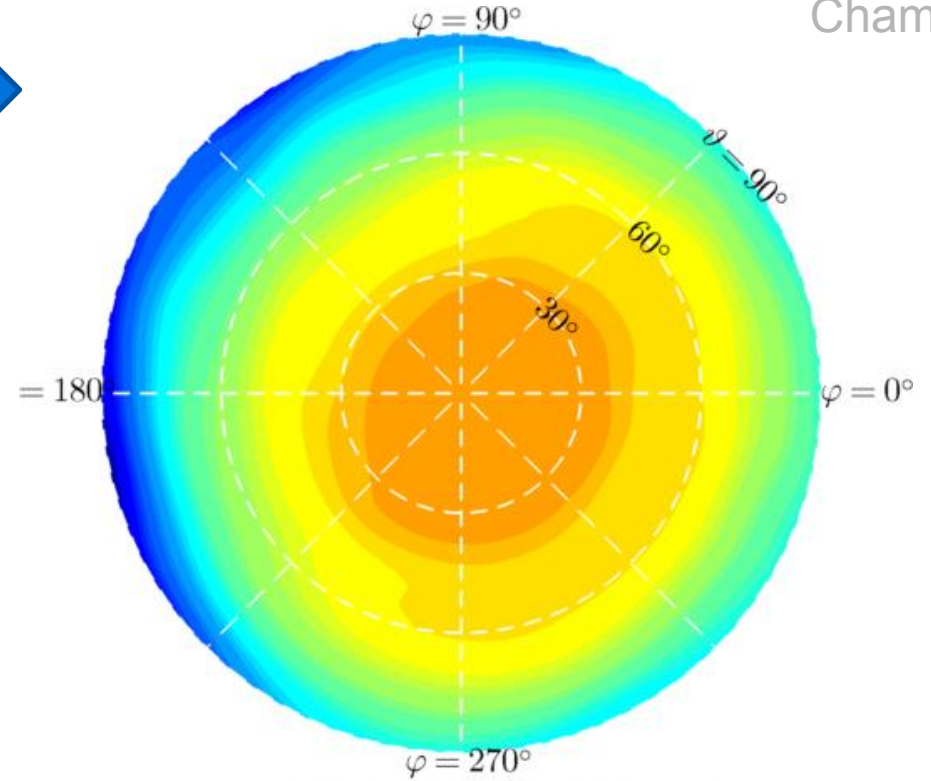


3.3 Variant A: Satellite Antenna Performance 3D-Chart (GNSS L1)

Chamber



AUT LHCP gain at 1575MHz / dBi

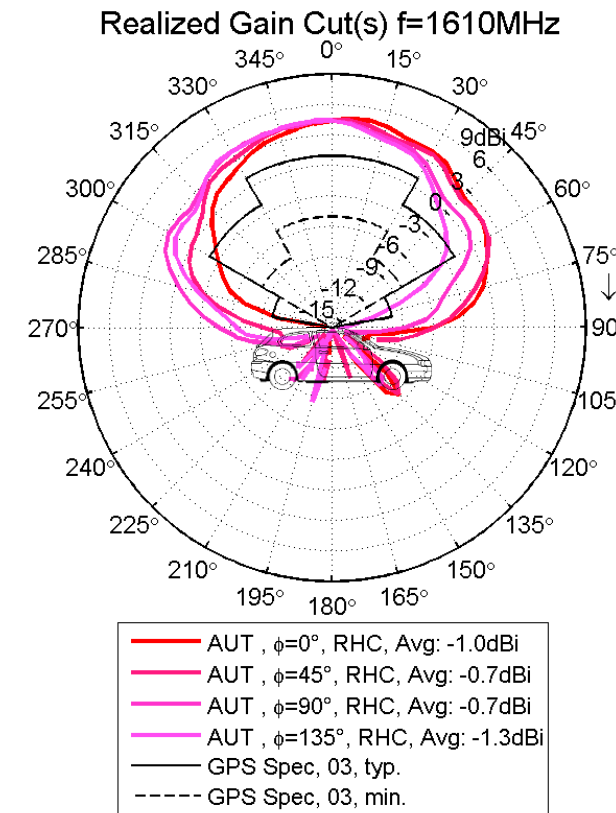
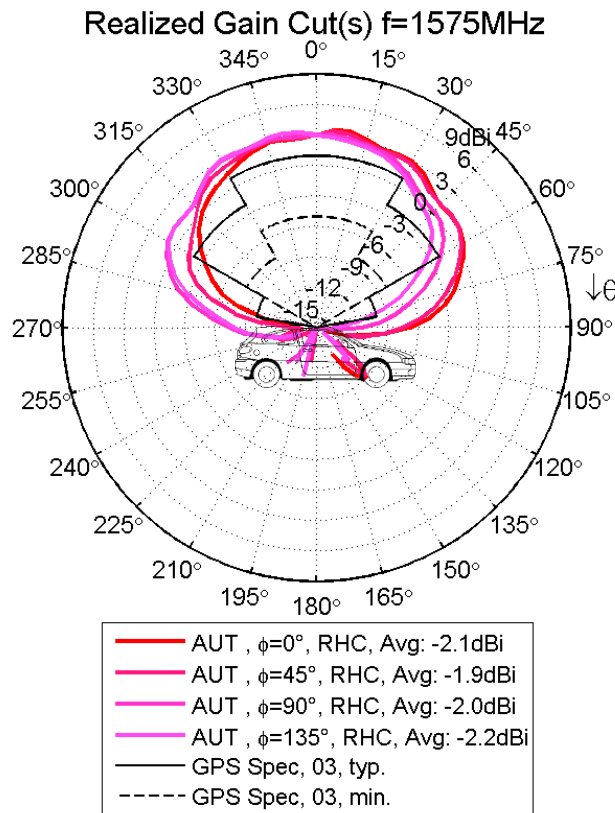
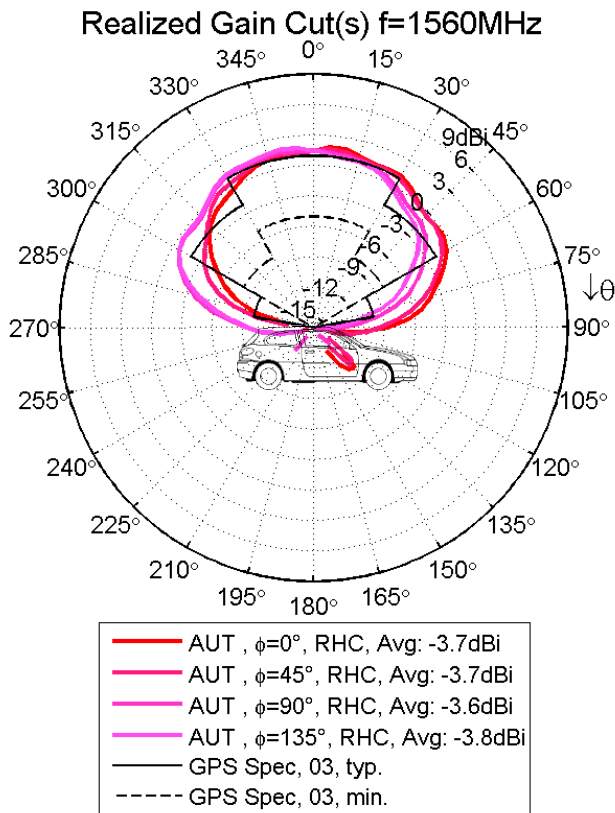


AUT RHCP gain at 1575MHz / dBi



3.3 Variant A: Satellite Antenna Performance Gain-Cuts (GNSS L1)

Chamber

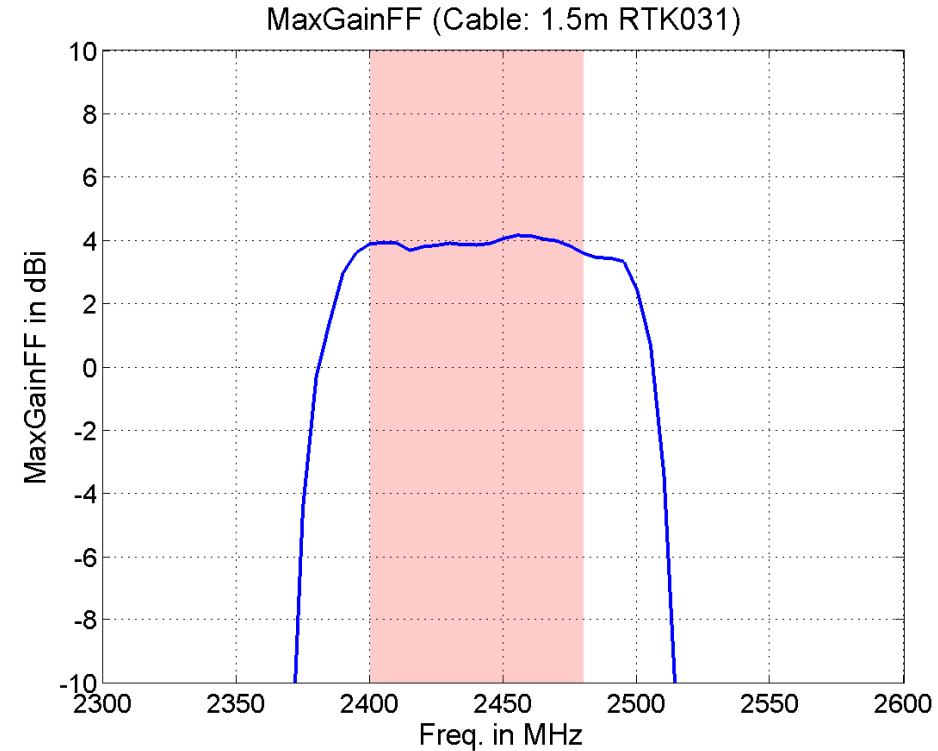
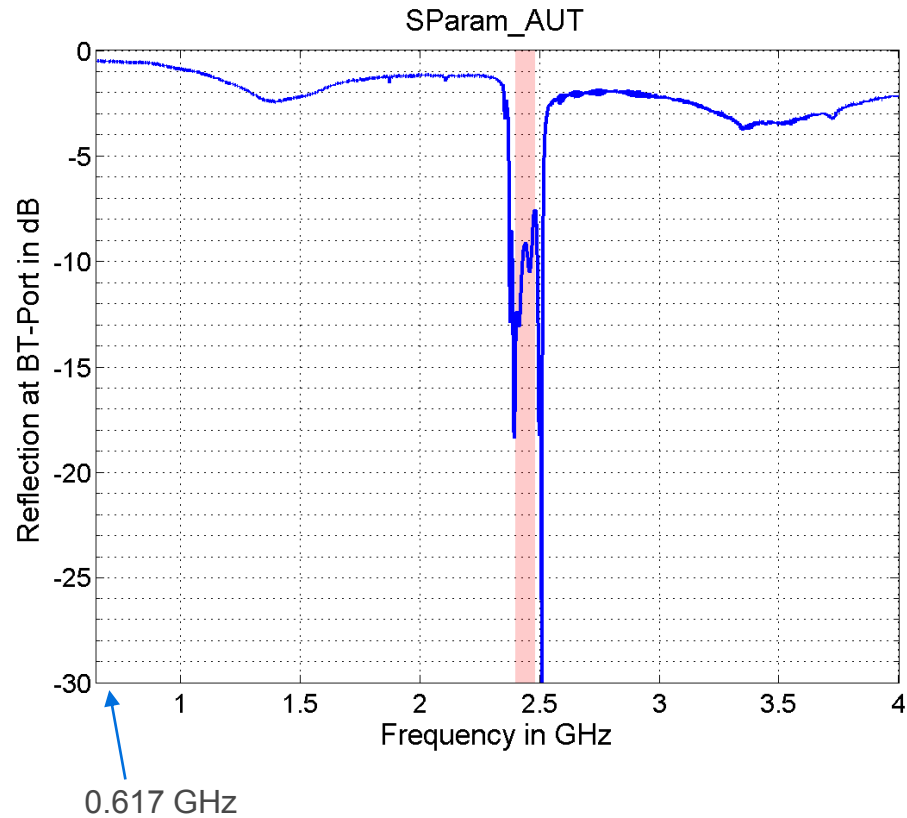


3.4 Bluetooth



3.4 Variant A: Bluetooth Antenna Performance Matching (BT)

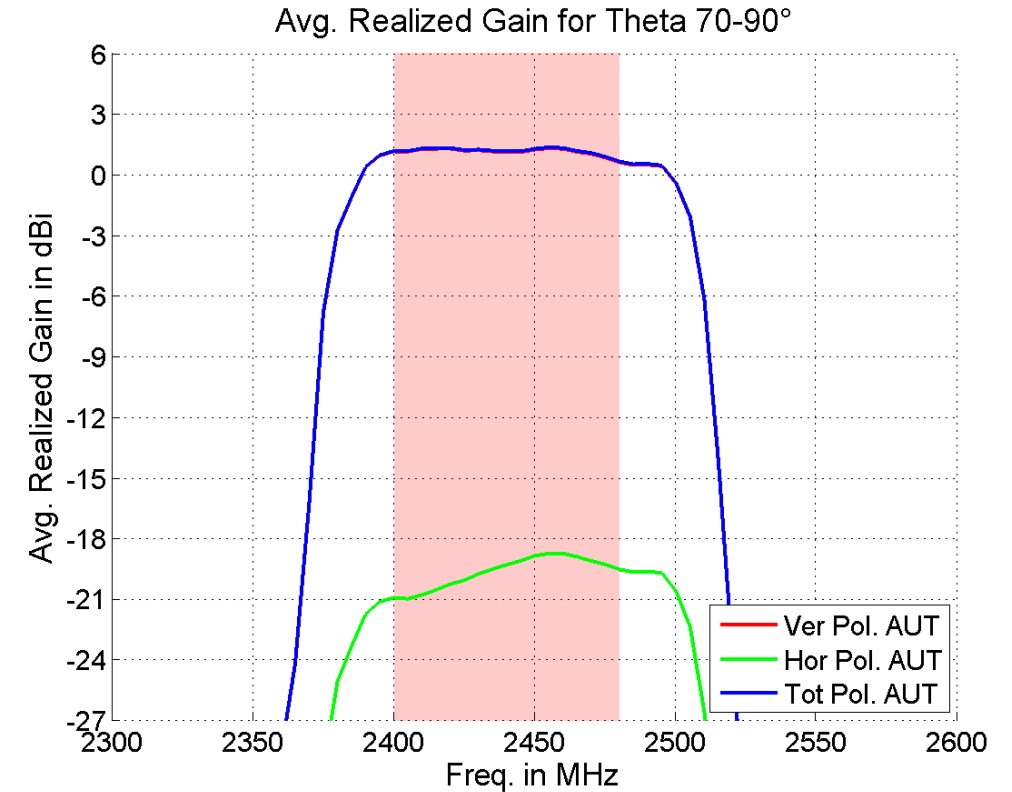
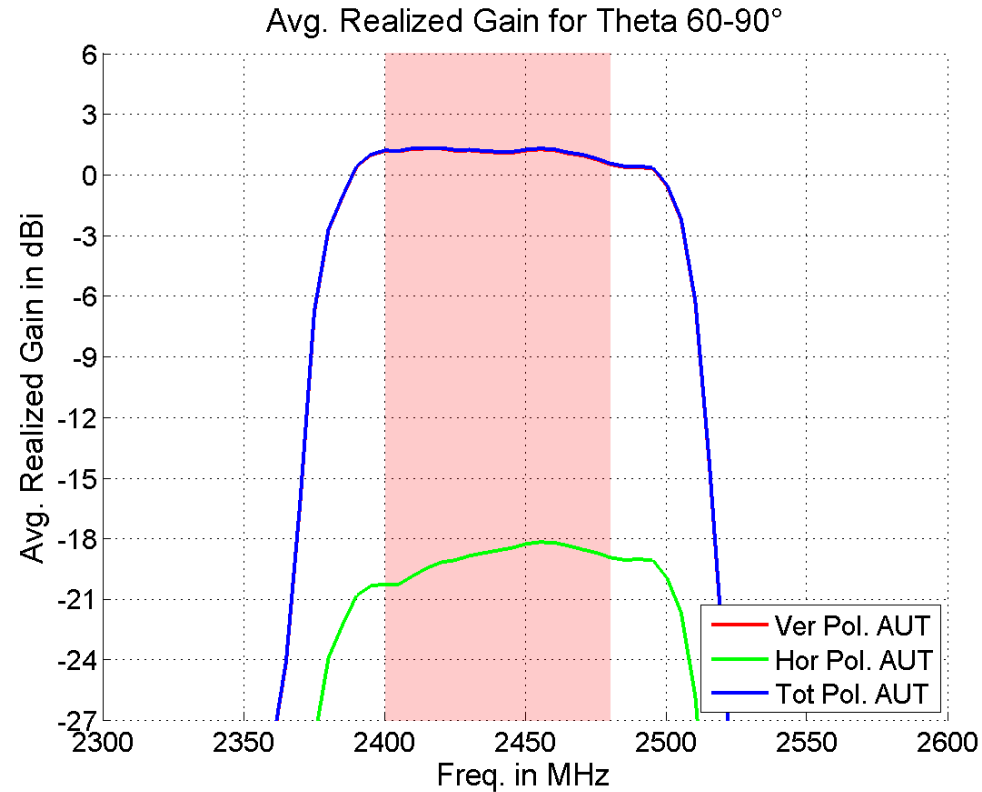
Chamber



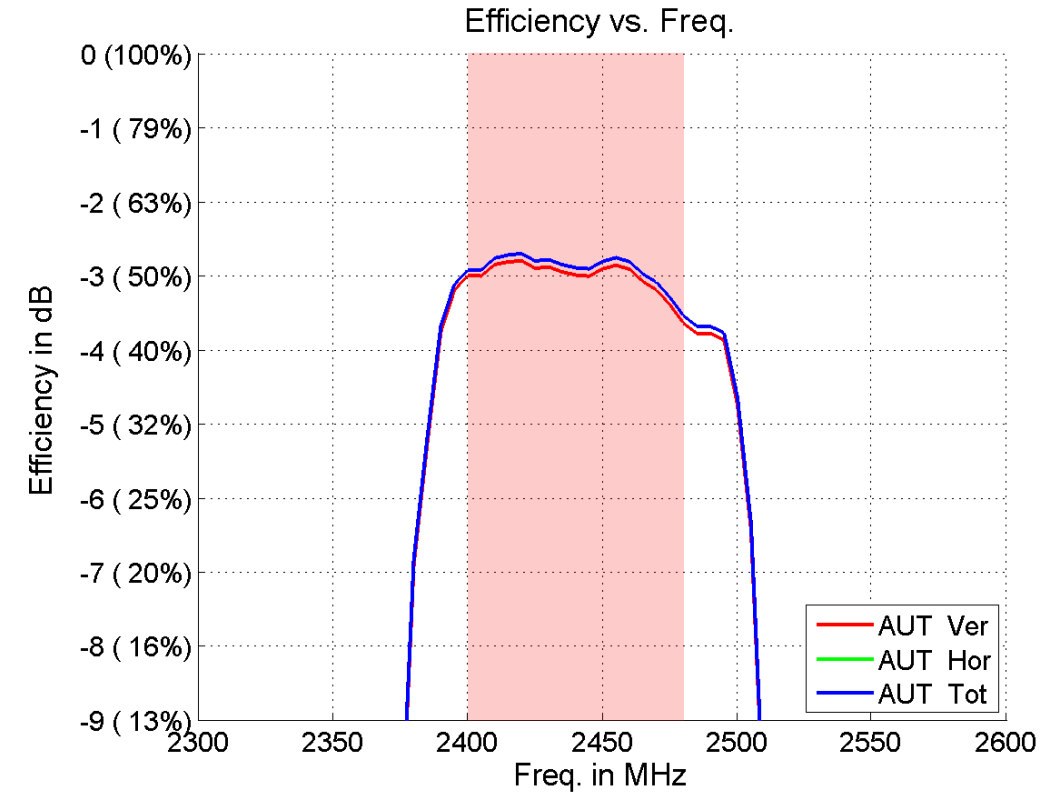
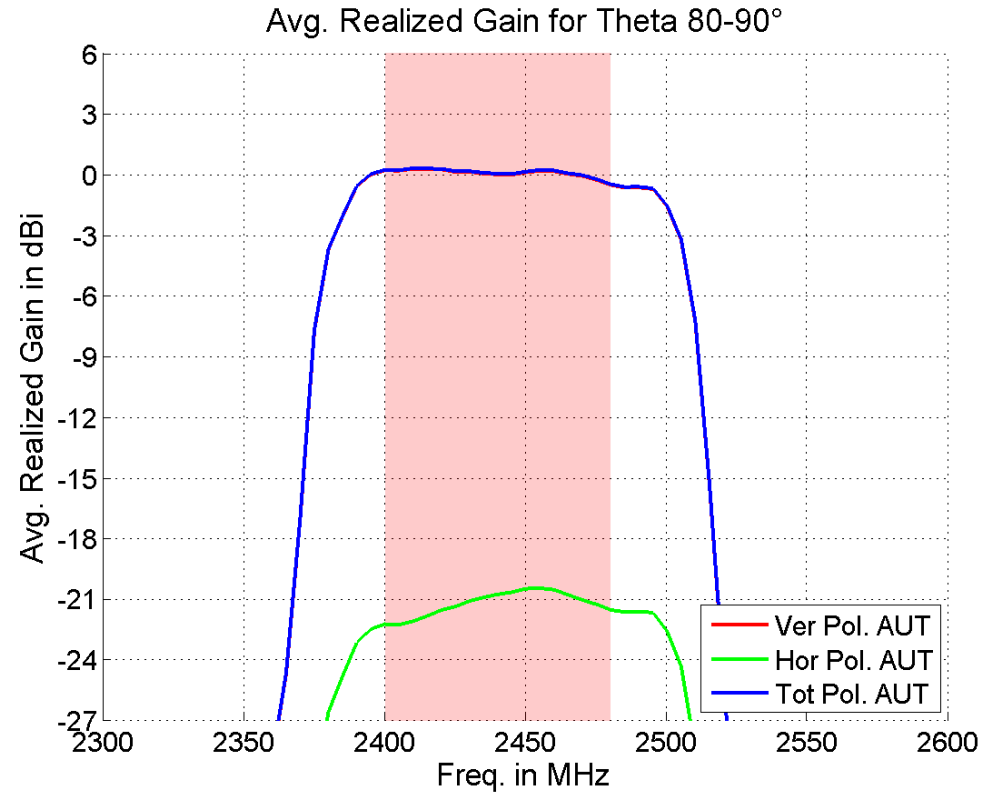
- The MaxGainFF-values are determined with 1.5m RTK031 cable (attenuation added to the measurement results).
- See attached file “Audi_CS_S11_VariantA_BT_gain_maxFF.csv” for the equivalent raw MaxGainFF-data.



3.4 Variant A: Bluetooth Antenna Performance Gain and Efficiency (BT)

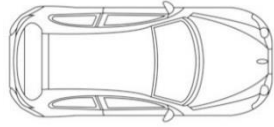


3.4 Variant A: Bluetooth Antenna Performance Gain and Efficiency (BT)

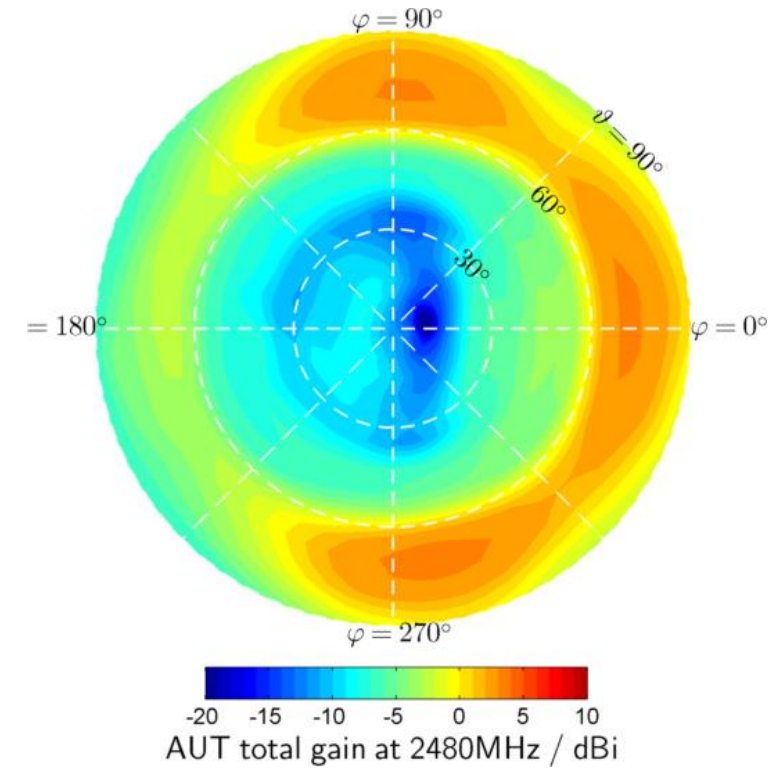
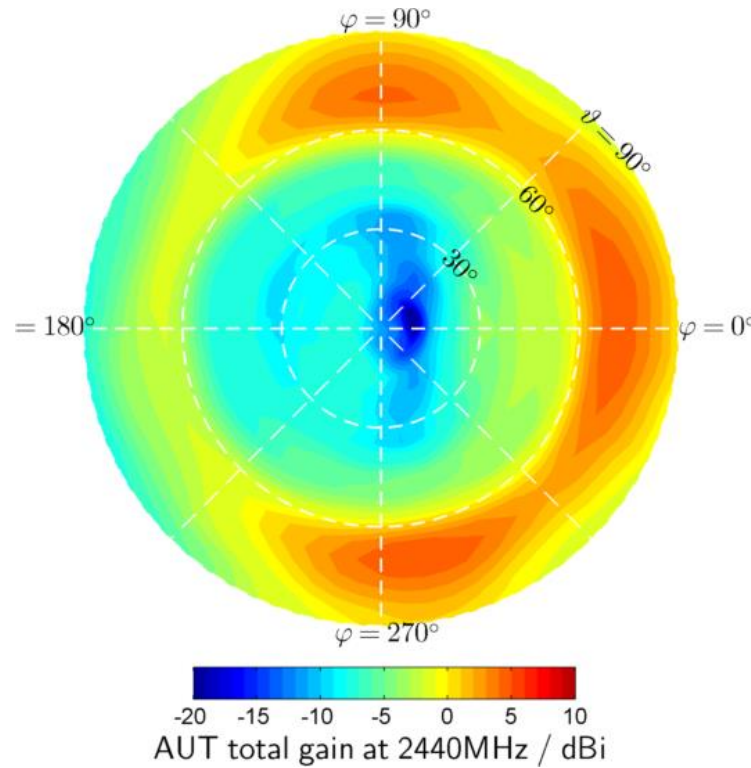
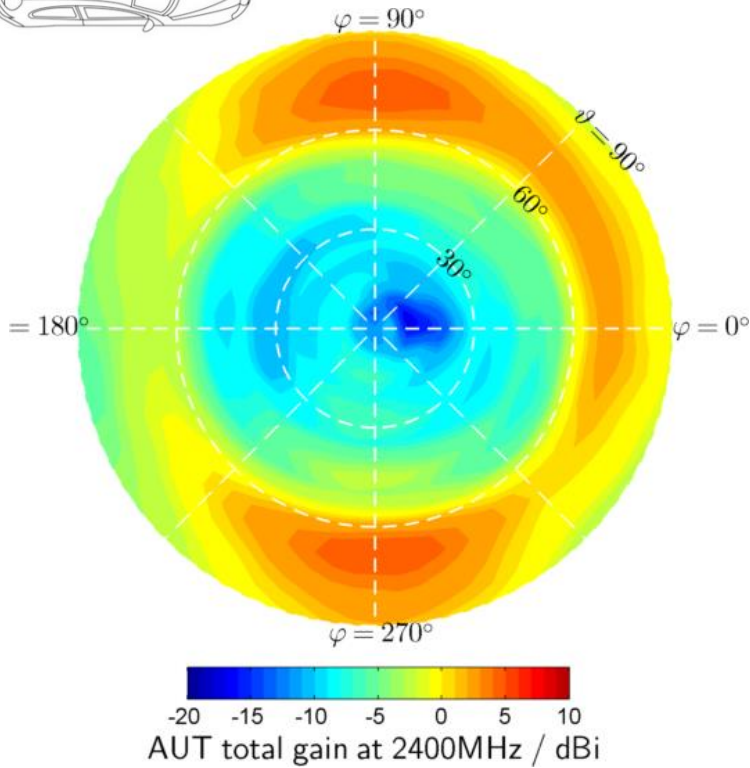


3.4 Variant A: Bluetooth Antenna Performance 3D-Chart (BT)

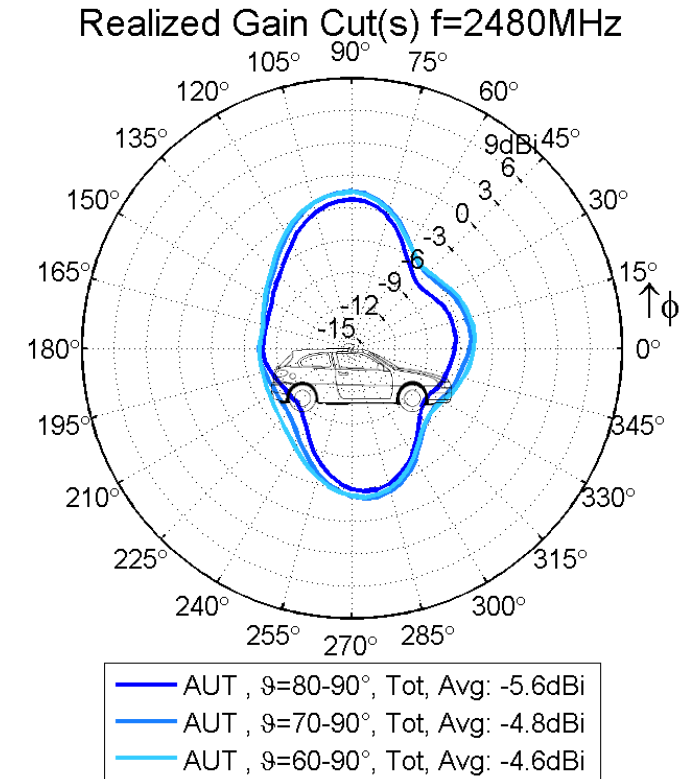
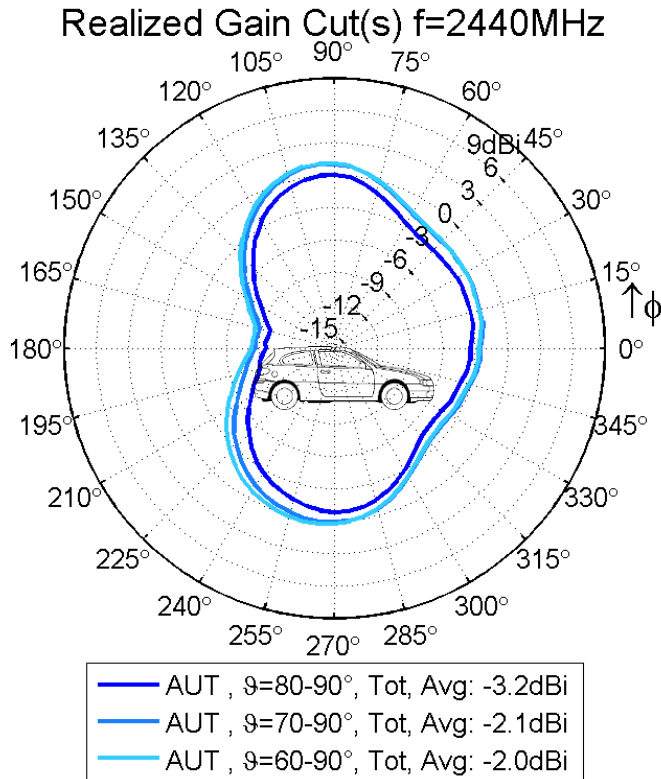
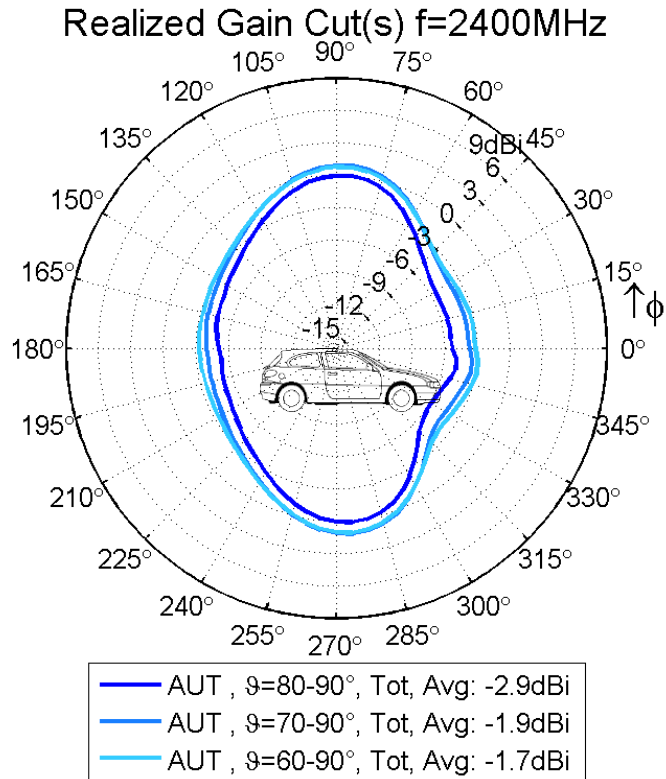
Chamber



Driving Direction



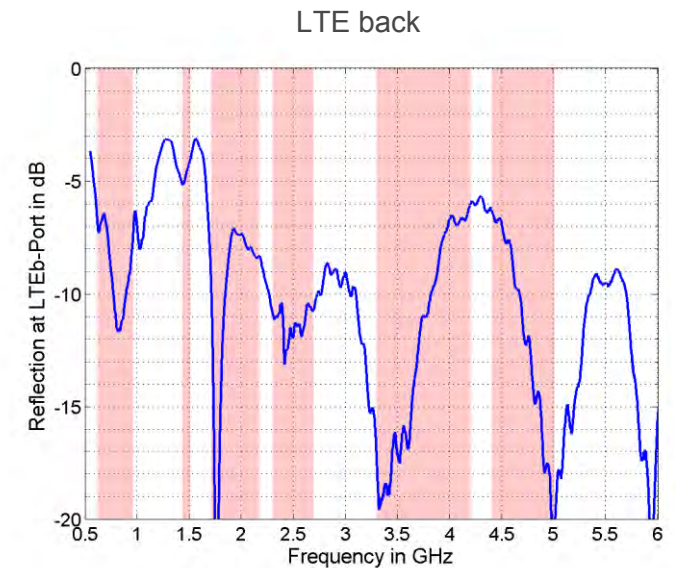
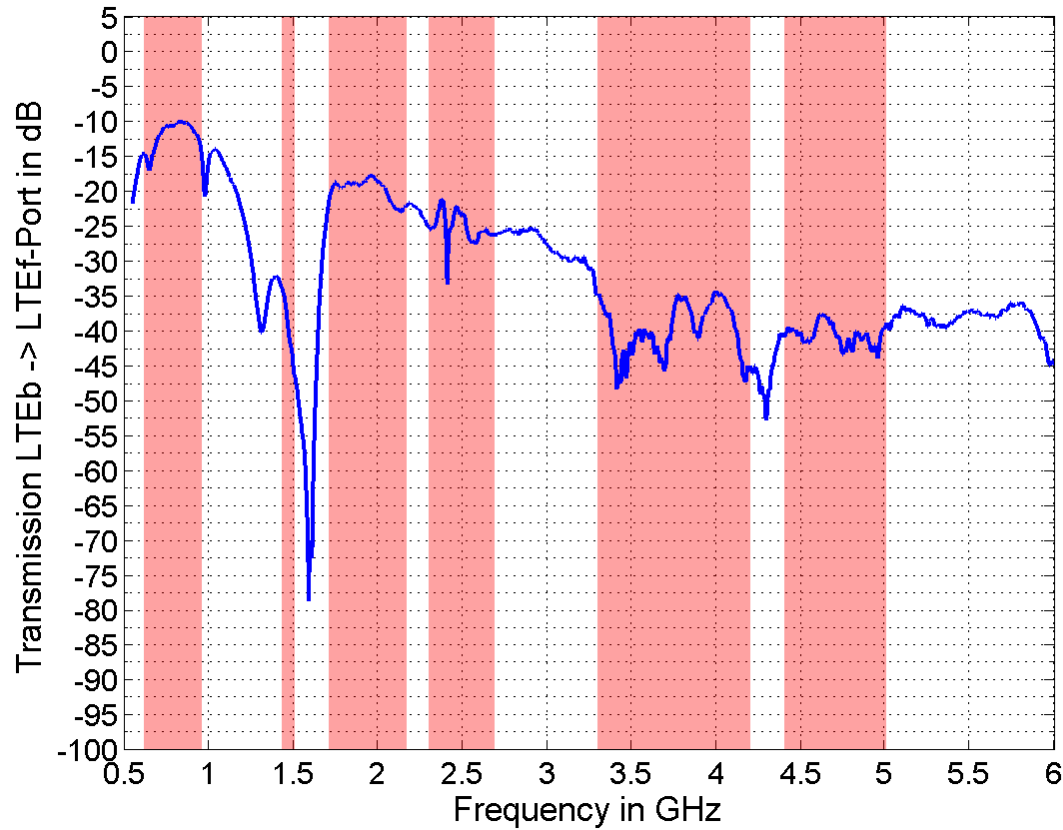
3.4 Variant A: Bluetooth Antenna Performance Gain-Cuts (BT)



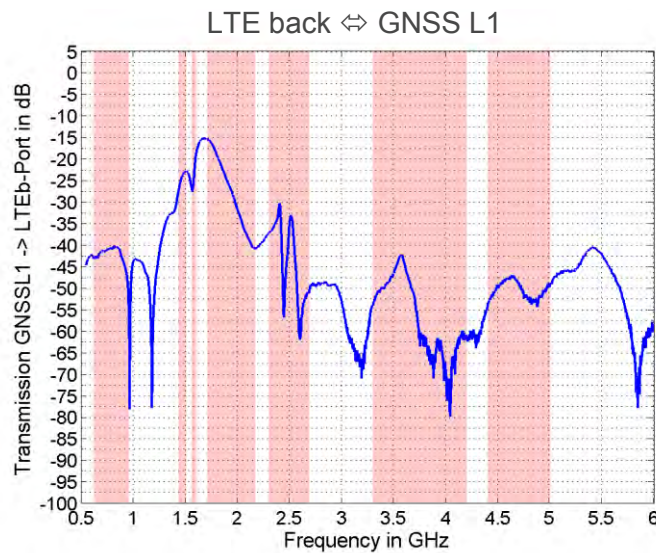
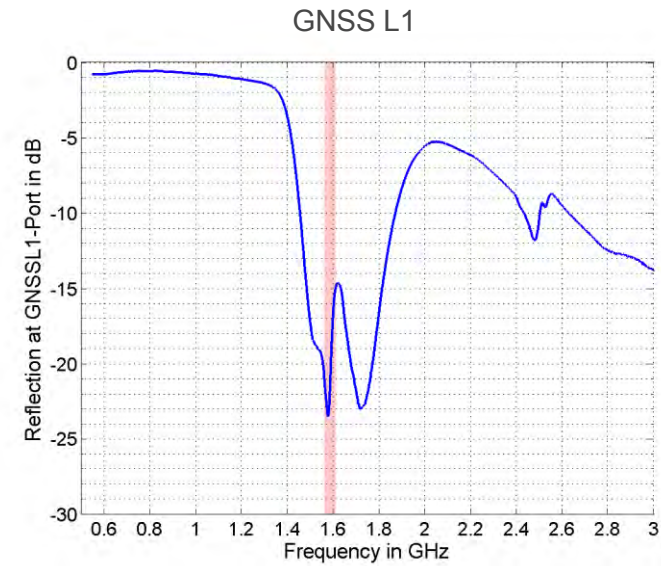
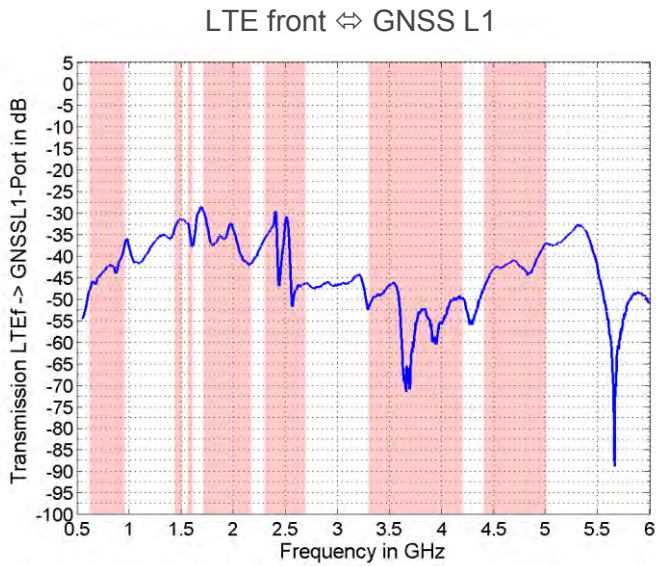
3.5 Decoupling



3.5 Variant A: Decoupling LTE front <=> LTE back

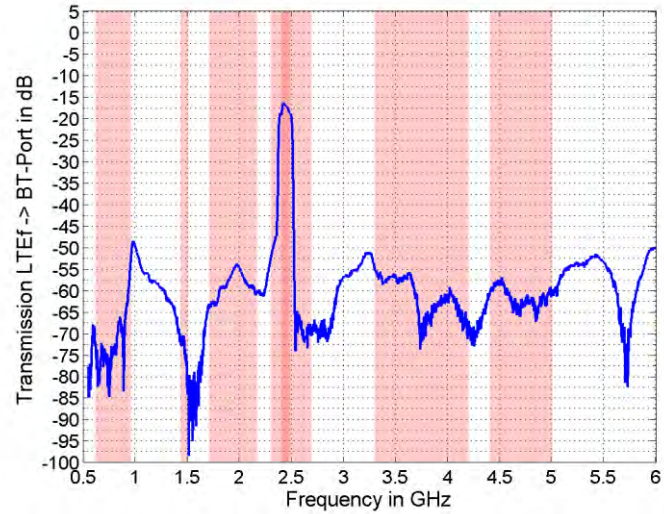


3.5 Variant A: Decoupling LTEs <=> SATs

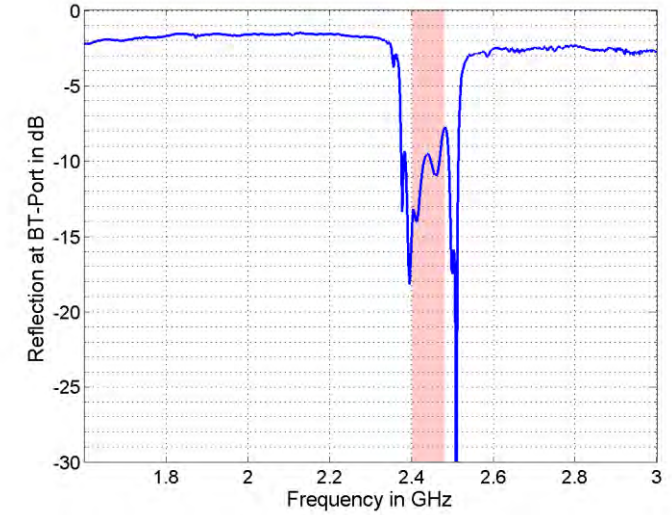


3.5 Variant A: Decoupling BT <=> LTEs/SATs

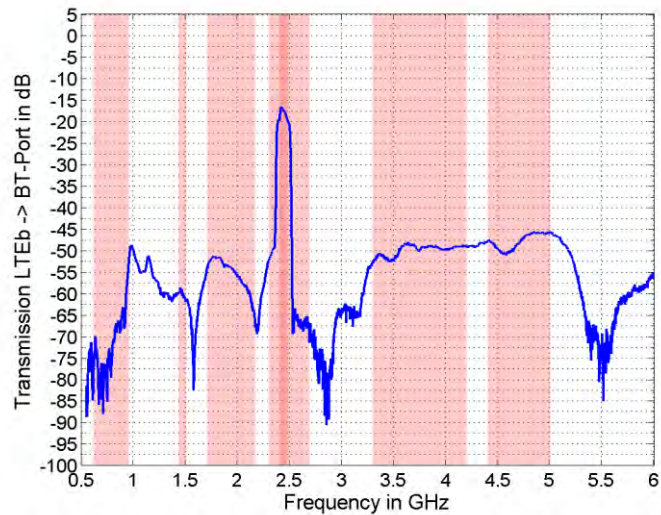
LTE front ↔ BT



BT



LTE back ↔ BT



GNSS L1 ↔ BT

