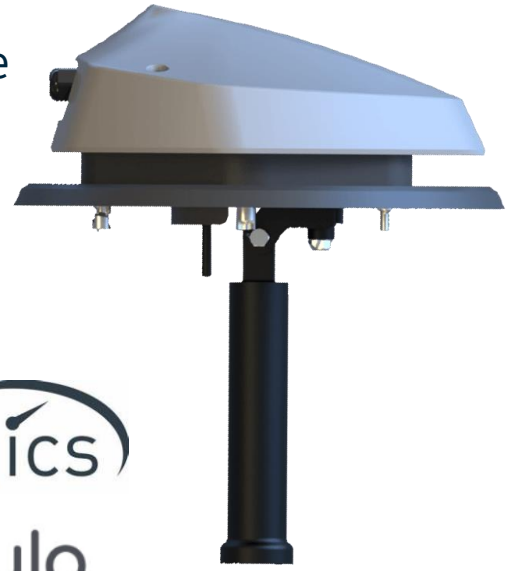
TAOGLAS®

LvLogics SiloSpi Device

Passive Antenna Chamber Testing



LvLogics

skylo

SIERRA WIRELESS®
A SEMTECH COMPANY

2023/10/10

Specifications

Skylo offers a global satellite NB-IoT network including the NTN bands

Operating Bands:

Band	FWD (UE Rx)	RTN (UE Tx)	Separation	Region
Band 255	1525-1559 MHz	1626.5-1660.5 MHz	-101.5 MHz	Global
Band 256	2170-2200 MHz	1980-2010 MHz	190 MHz	Europe
Band 23	2180-2200 MHz	2000-2020 MHz	180 MHz	North America

Table 1. Skylo deployment band configuration

Antenna performance Target:

Type 1 NB-IoT Requirements: Free Space

Band	TRP (dBm)	TIS (dBm)
Band 255	≥ 20	≤ -112 dBm
Band 256	≥ 20	≤ -112 dBm
Band 23	≥ 20	≤ -112 dBm

Table 2. Type 1 device performance criteria

Introduction

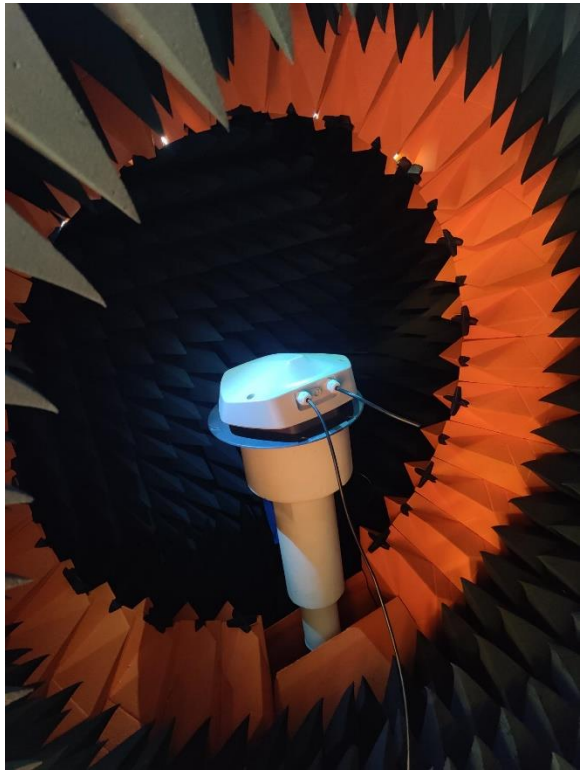
- Taoglas has performed different antenna integrations in the device provided by LvLogics.

- In this report two different solutions with PCB based antennas and flexible antennas are analyzed.

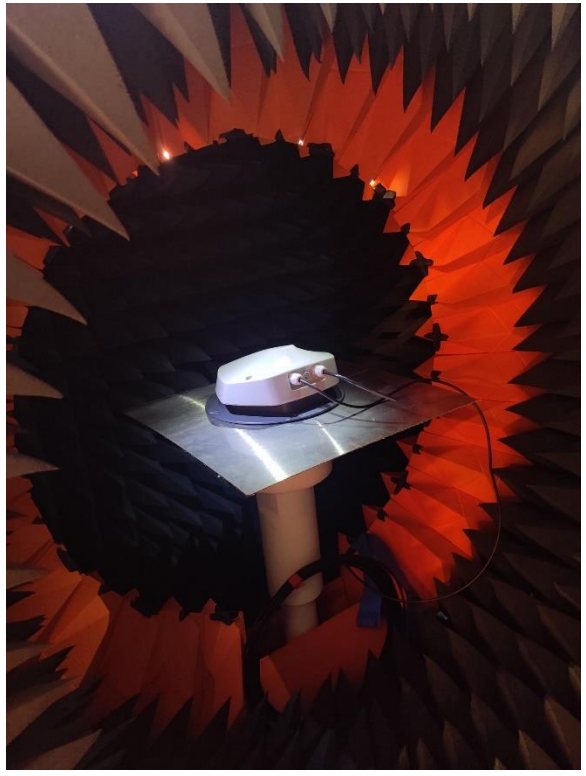
- The device will be placed on a metallic structure which will interfere in the antenna performance. A similar set-up measurement has been carried out in order to emulate a real environment.

PA.26A PCB Initial Point

Overview SiloSpi Device



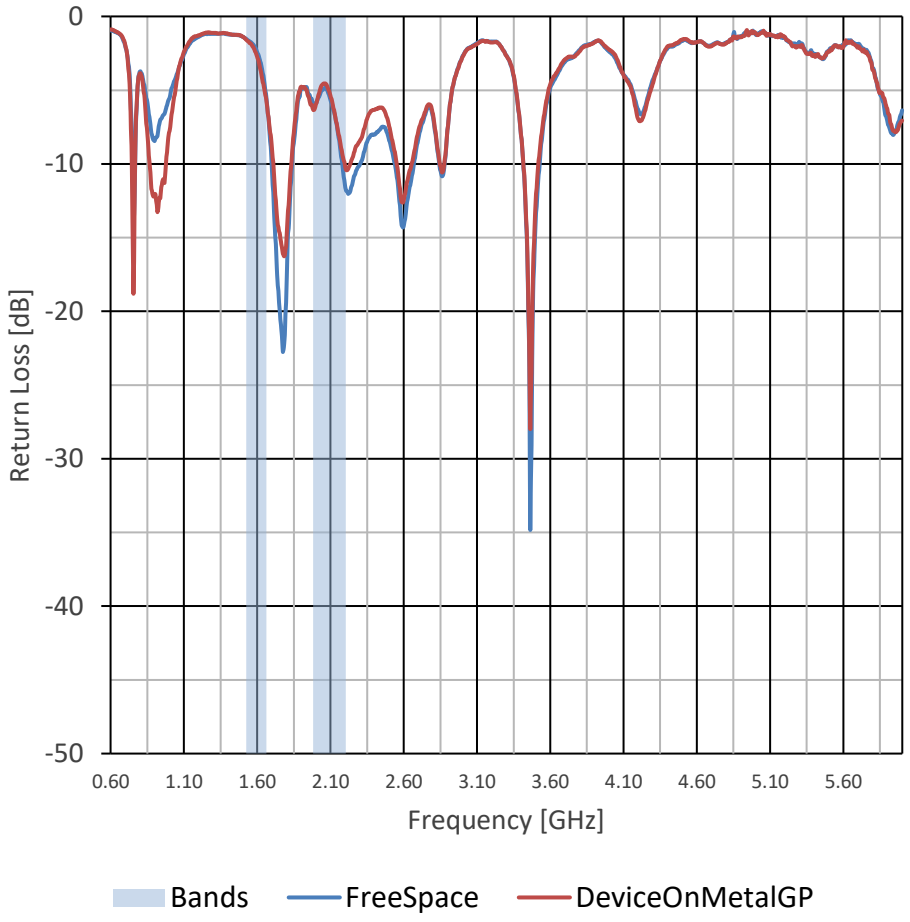
Device standing alone



Device on a metallic Ground Plane

- The device has been measured standing alone (free space) and on a 70x70 cm metallic ground plane to emulate a real installation environment
- The initial test has been carried out with a PCB including the PA26A antenna.

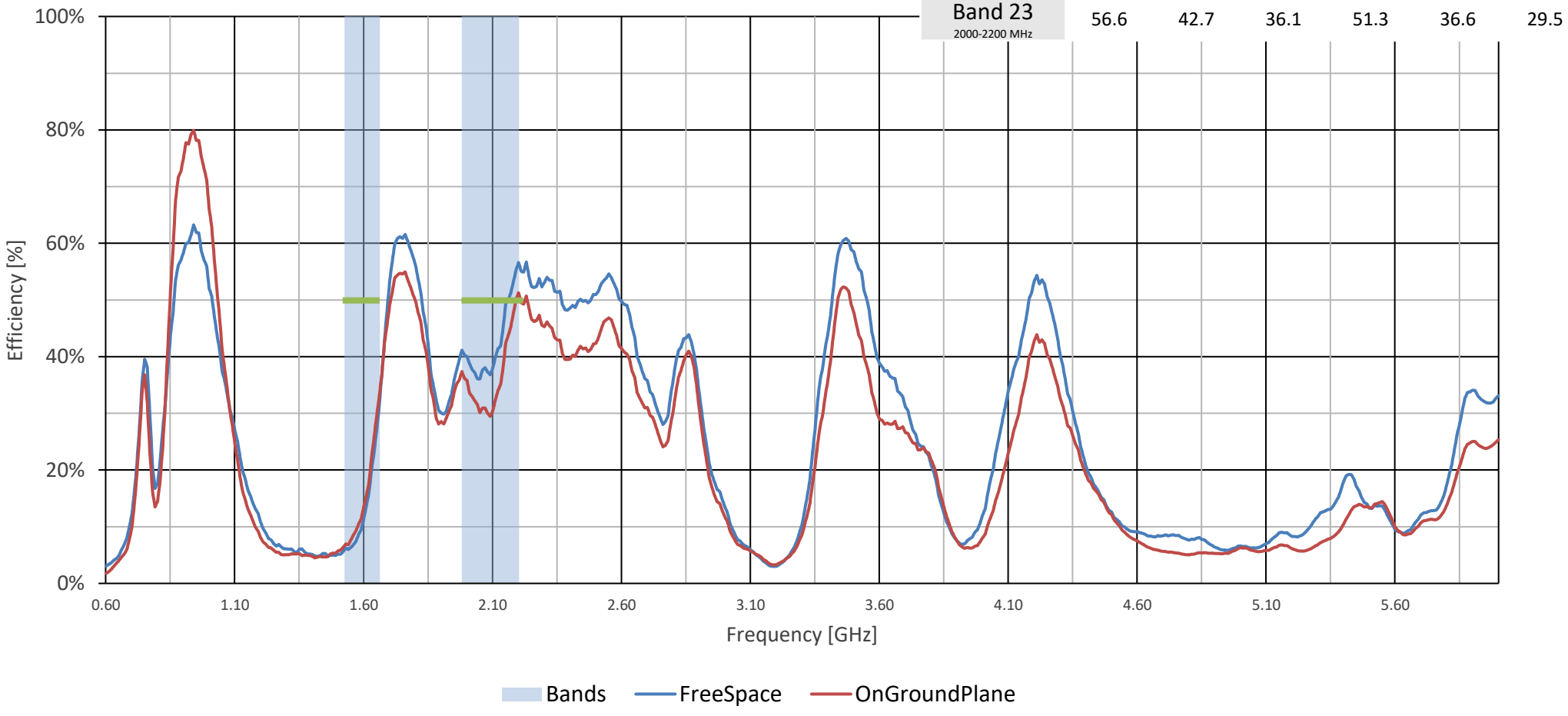
Return Loss SiloSpi Device



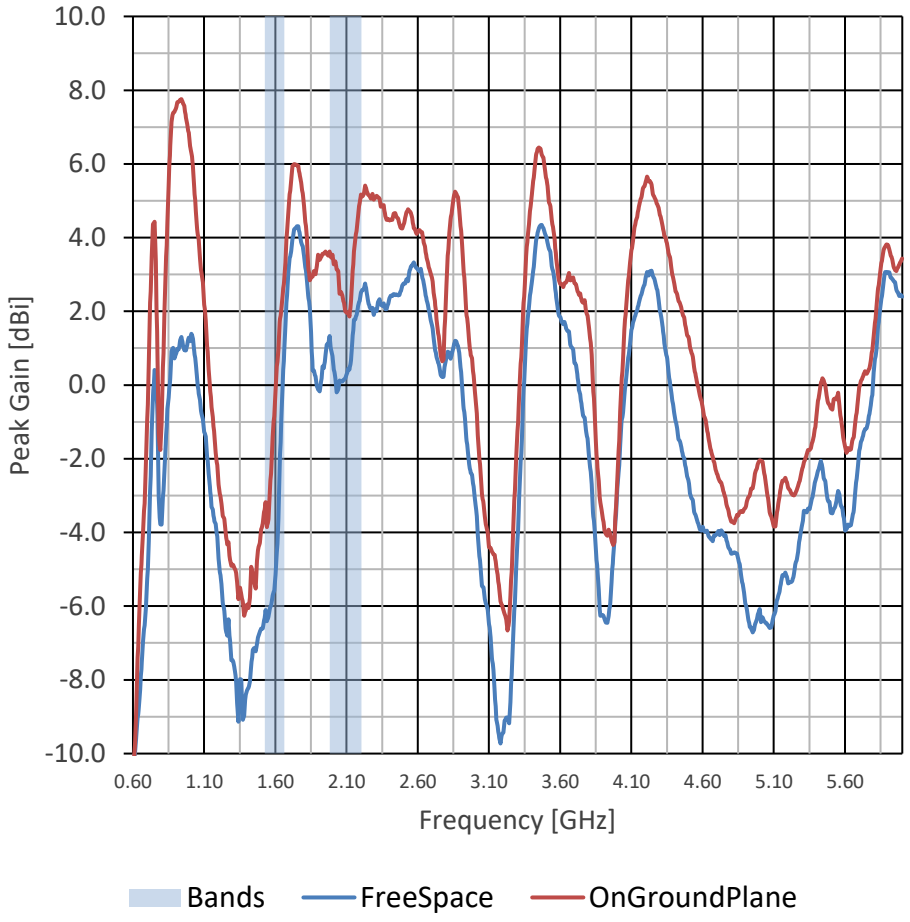
	FreeSpace			DeviceOnMetalGP		
Band	Max	Mean	Min	Max	Mean	Min
Band 255 1525-1660 MHz	-1.6	-2.7	-5.4	-1.7	-3.0	-5.6
Band 256 1980-2200 MHz	-4.8	-6.7	-11.6	-4.5	-6.4	-10.2
Band 23 2000-2200 MHz	-4.8	-6.8	-11.6	-4.5	-6.4	-10.2

Efficiency SiloSpi Device

	FreeSpace			OnGroundPlane		
Band	Max	Mean	Min	Max	Mean	Min
Band 255 1525-1660 MHz	31.5	13.9	6.0	33.1	15.6	6.8
Band 256 1980-2200 MHz	56.6	42.6	36.1	51.3	36.6	29.5
Band 23 2000-2200 MHz	56.6	42.7	36.1	51.3	36.6	29.5



Peak Gain SiloSpi Device for Gtotal



	FreeSpace			OnGroundPlane		
Band	Max	Mean	Min	Max	Mean	Min
Band 255 1525-1660 MHz	0.9	-4.1	-6.4	2.8	-0.6	-3.9
Band 256 1980-2200 MHz	2.5	0.8	-0.2	5.2	3.2	1.9
Band 23 2000-2200 MHz	2.5	0.8	-0.2	5.2	3.1	1.9

Band 255 Radiation Pattern @1592 MHz for [Gtotal]

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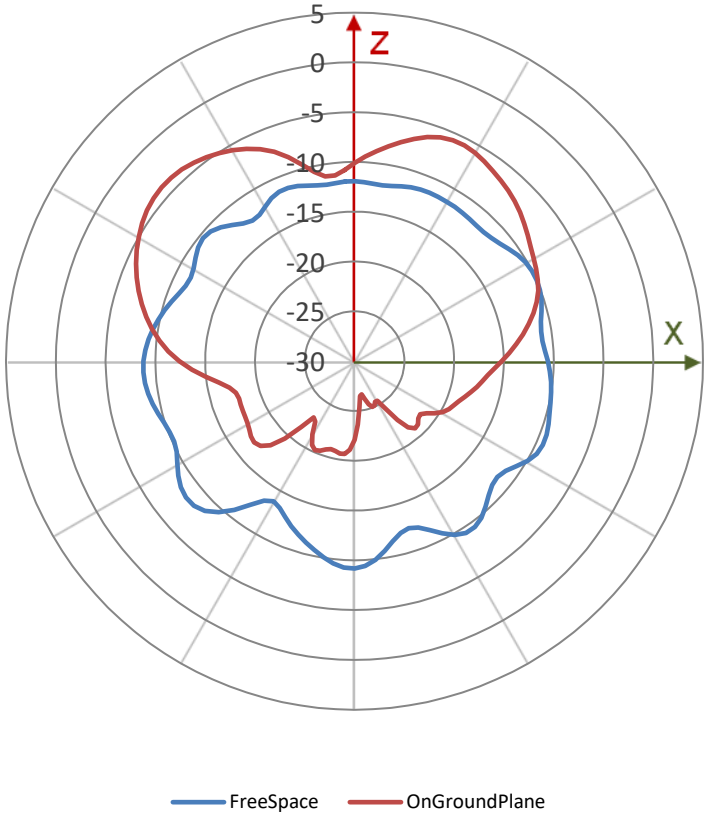

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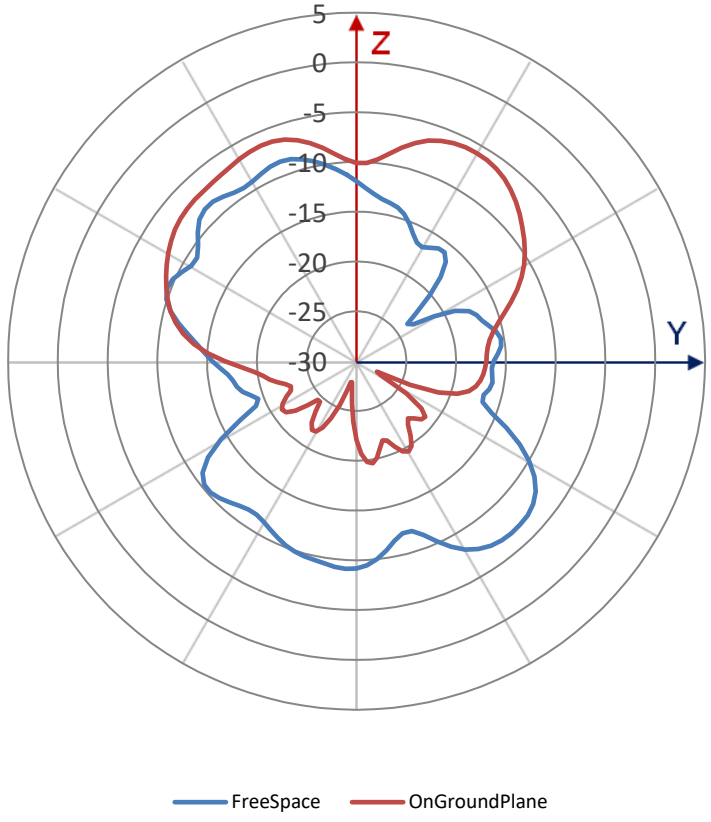

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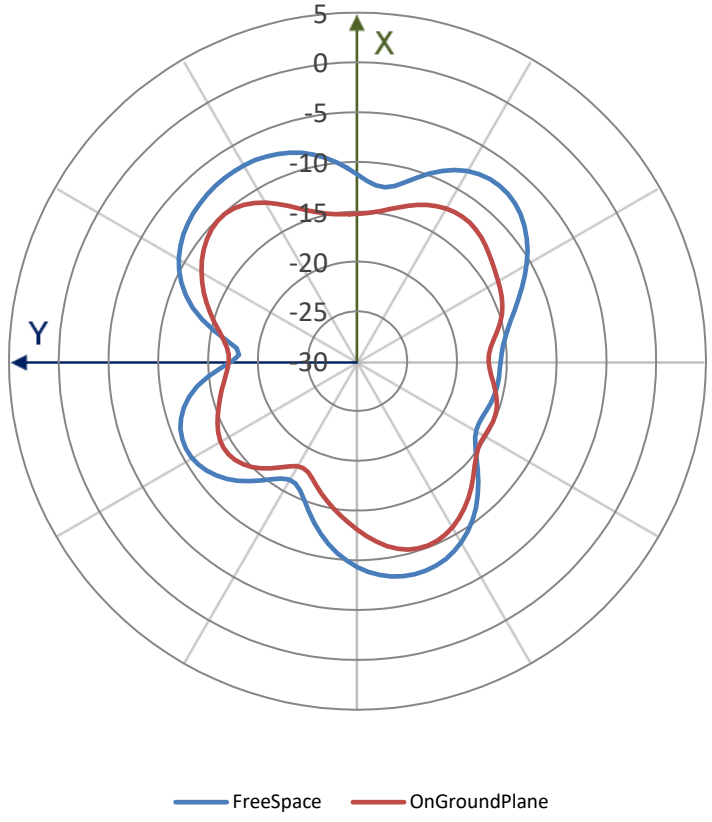
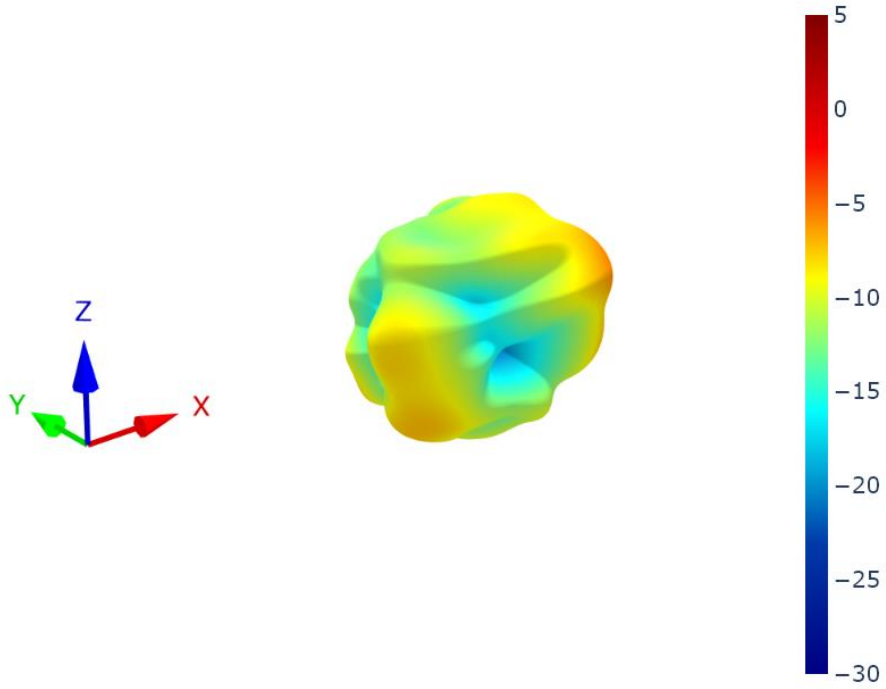
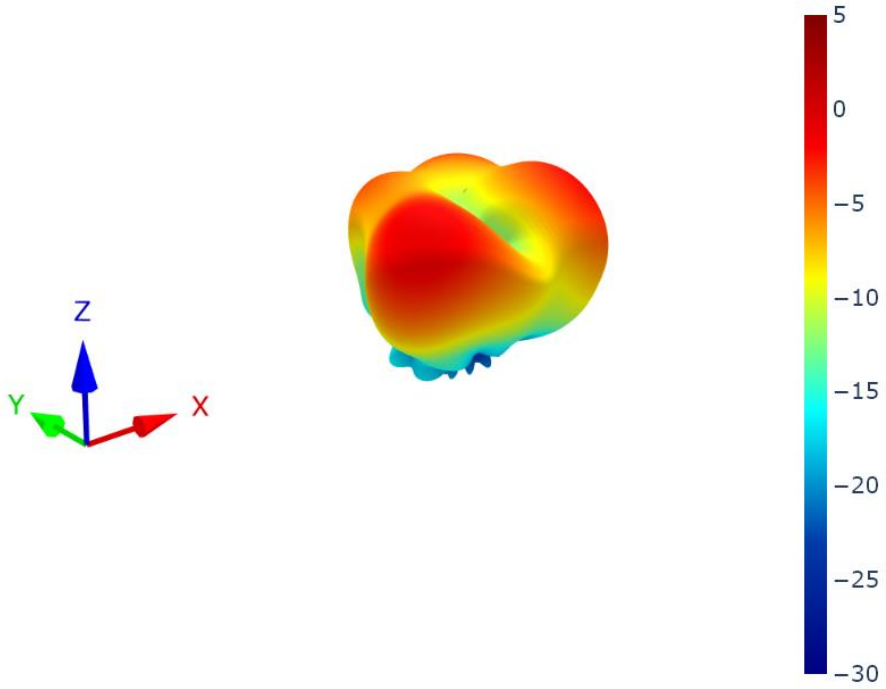


Band 255 3D Radiation Pattern @1592 MHz [Gtotal]



FreeSpace



OnGroundPlane

Band 256 Radiation Pattern @2090 MHz for [Gtotal]

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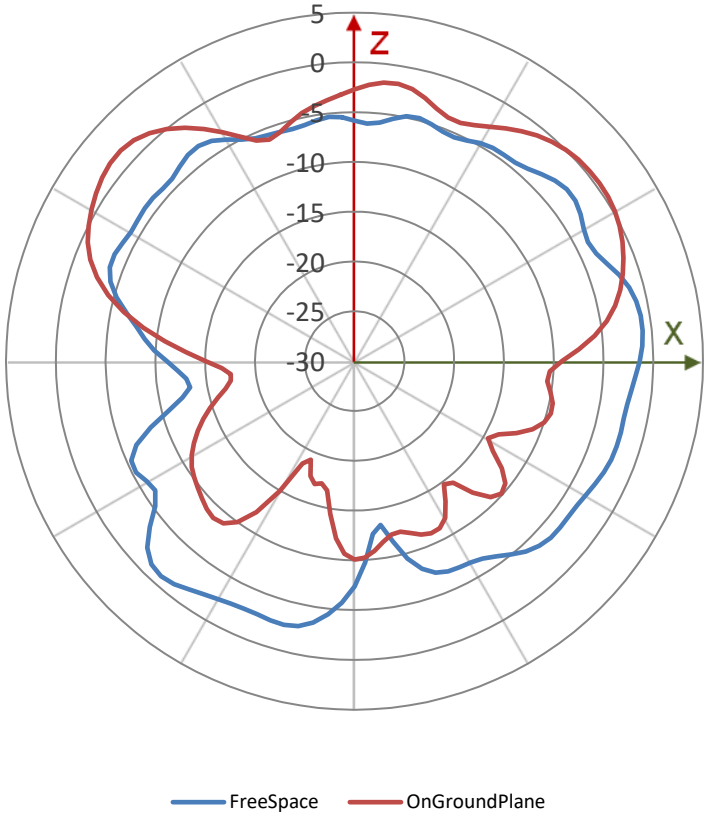

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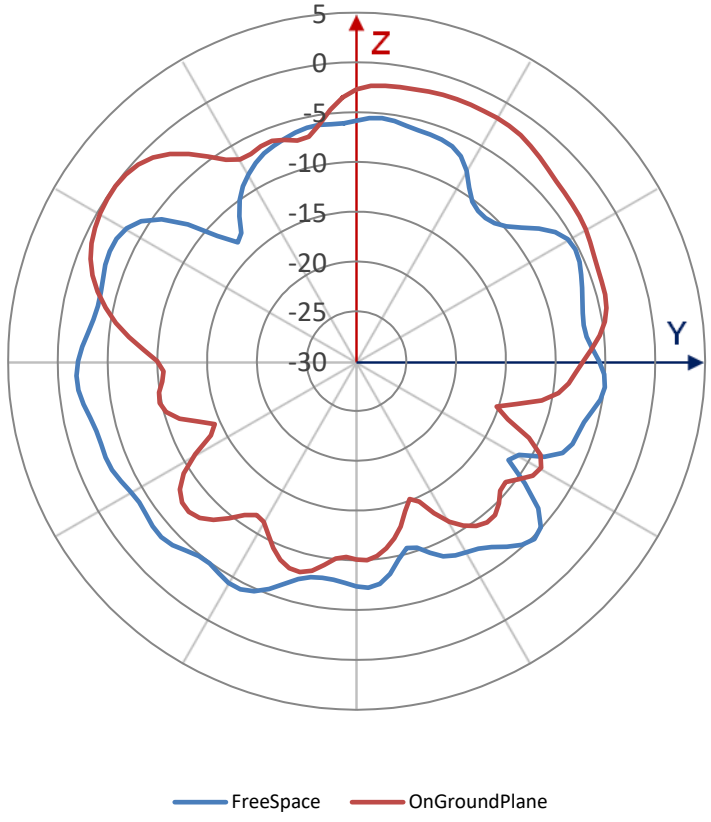

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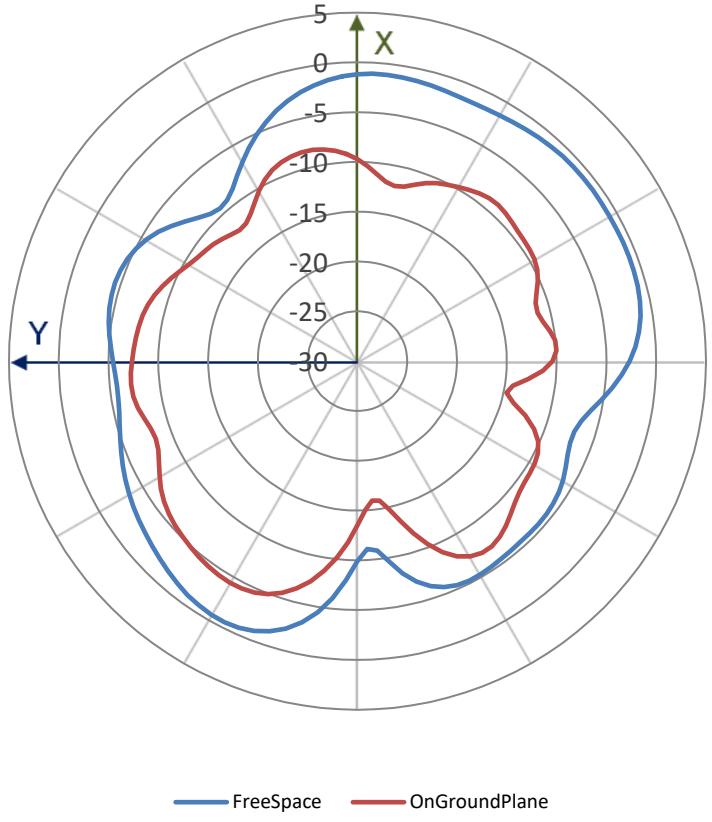
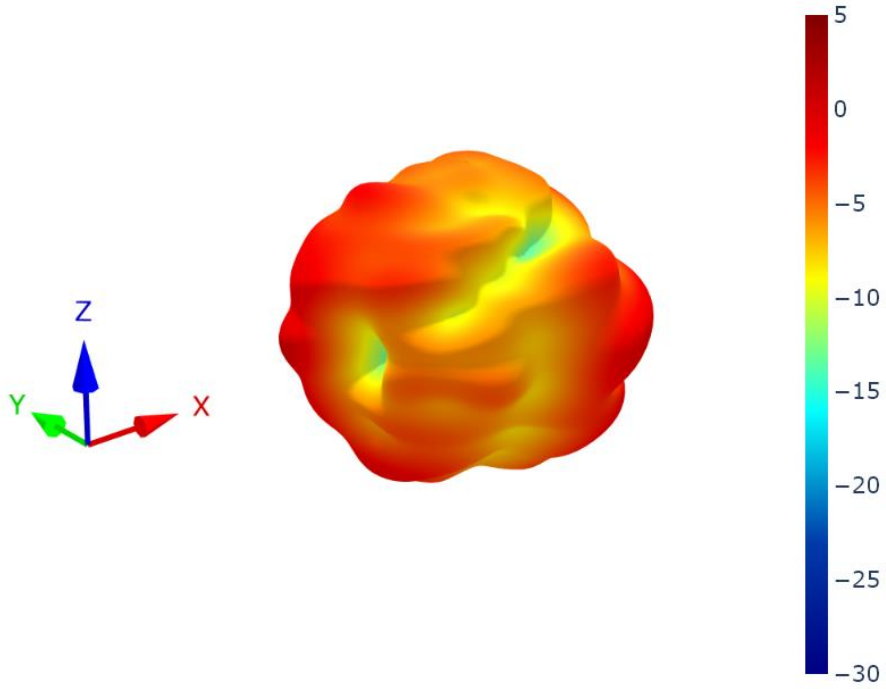
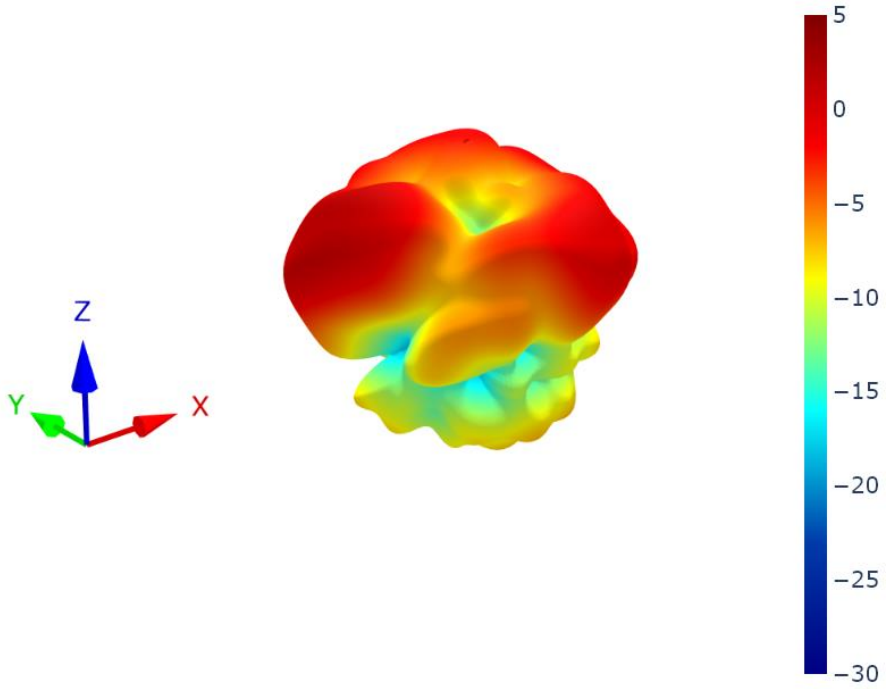


Band 256 3D Radiation Pattern @2090 MHz [Gtotal]



FreeSpace



OnGroundPlane

Band 23 Radiation Pattern @2100 MHz for [Gtotal]

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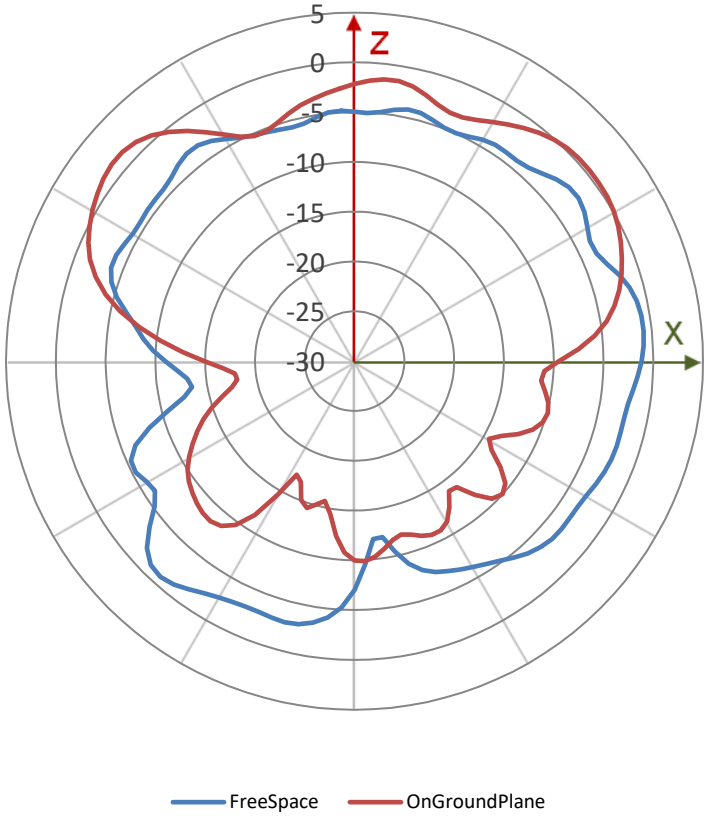
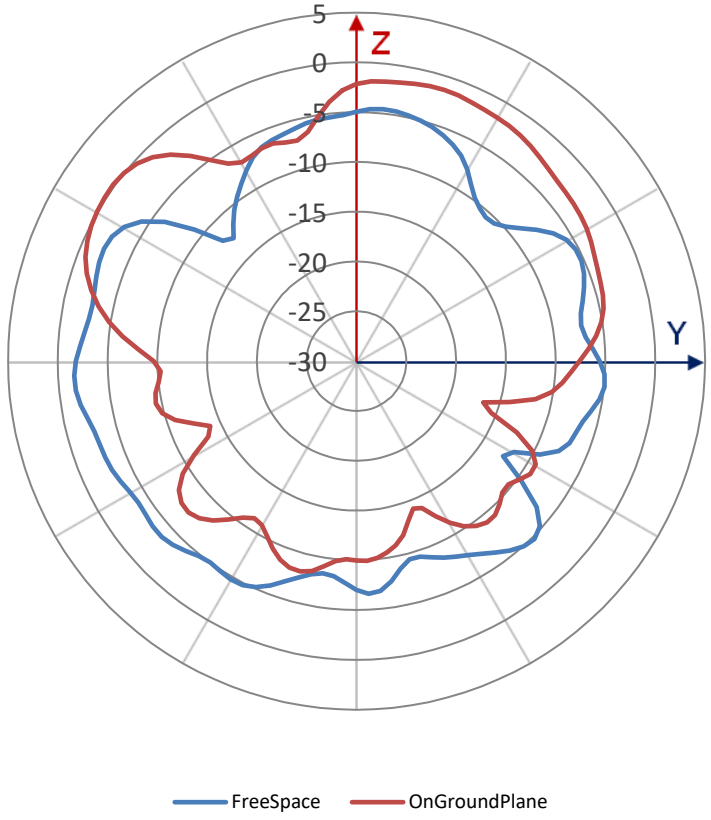


phi = 90



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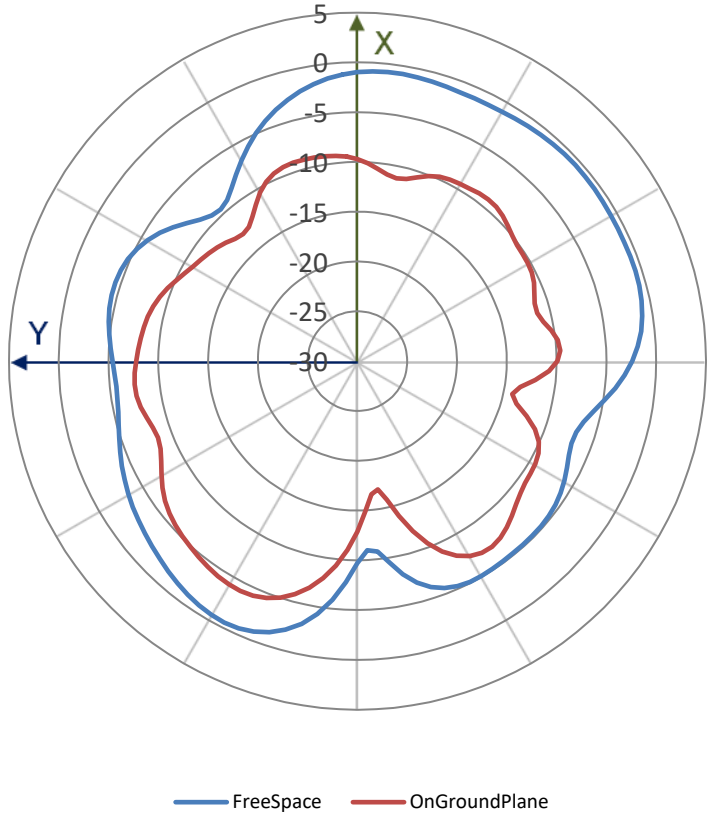
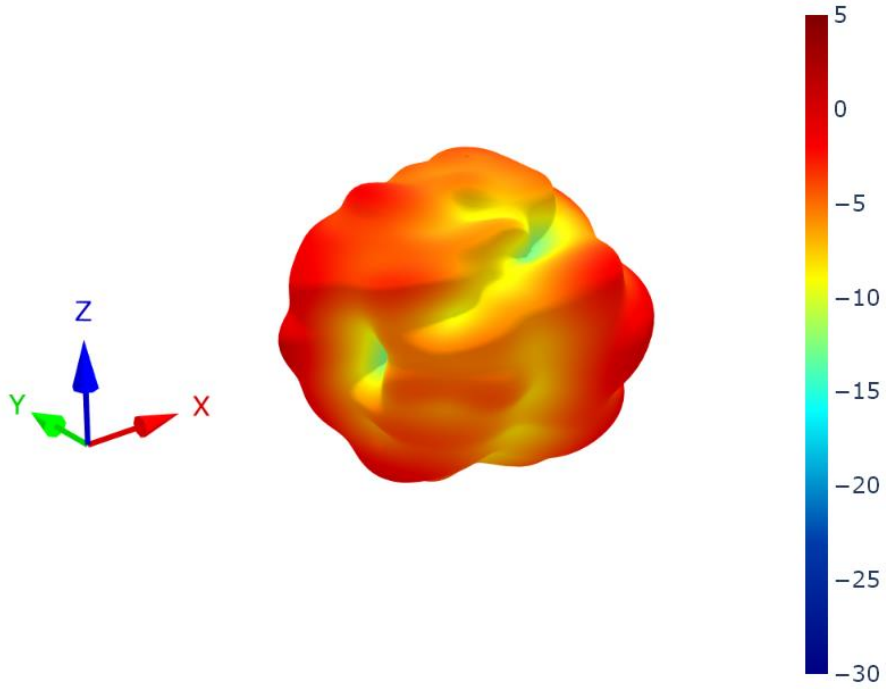
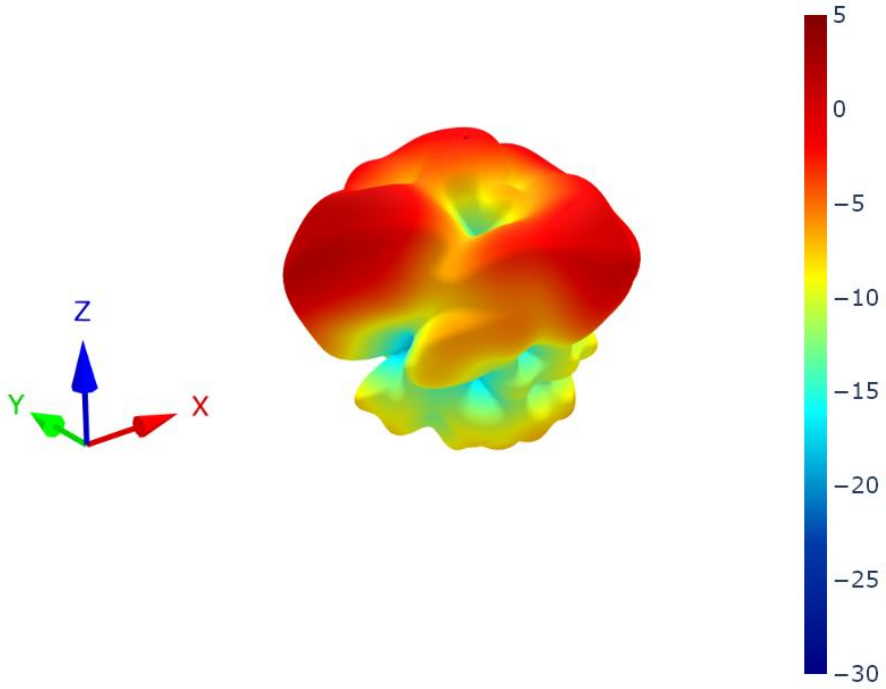


Band 23 3D Radiation Pattern @2100 MHz [Gtotal]



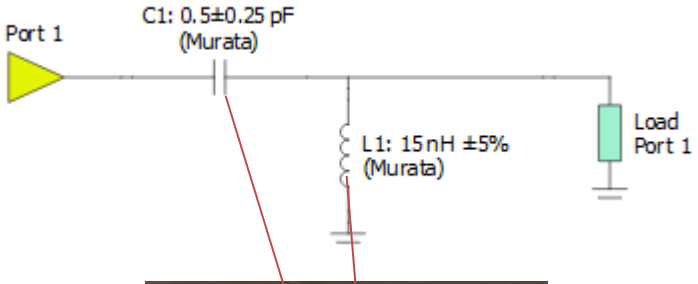
FreeSpace



OnGroundPlane

PA.26A PCB and Mods

Overview PA.26A with modification

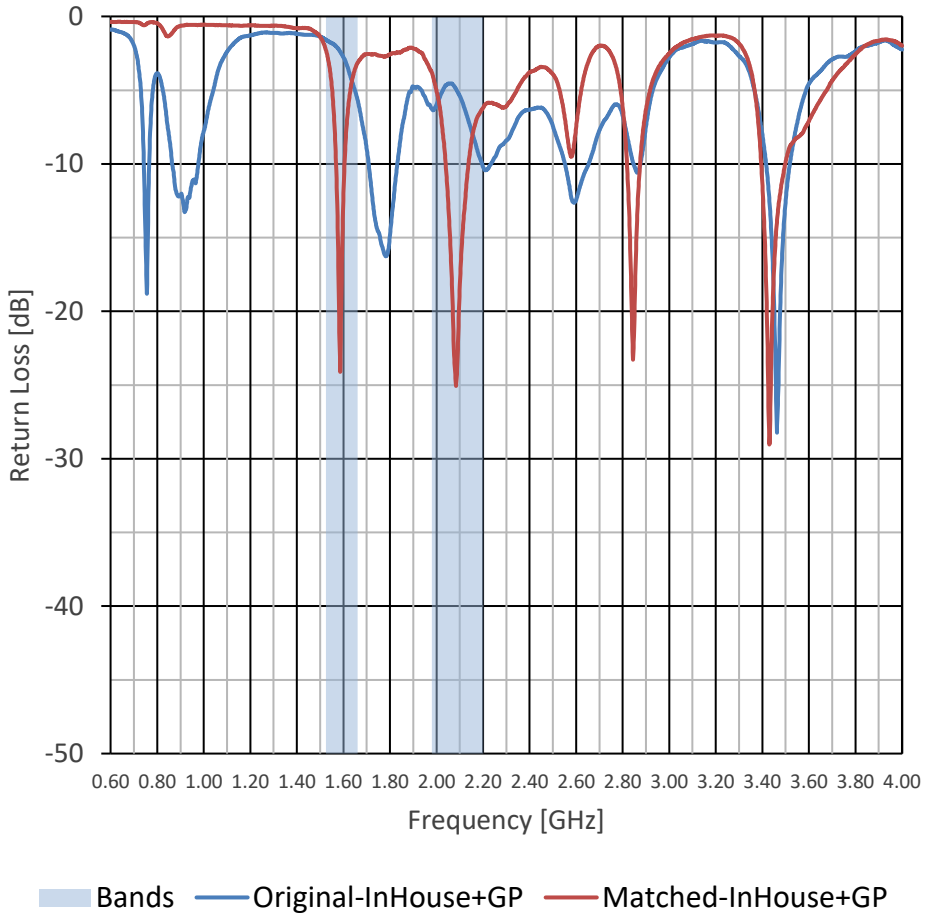


Original PA.26A

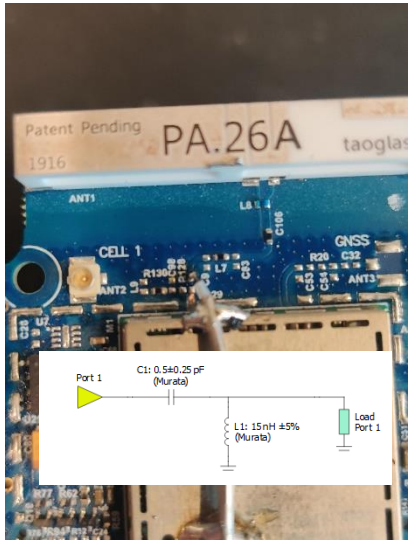
PA.26A with a L Matching Circuit

- Since the original antenna is not properly tuned for the NTN bands, a matching circuit has been calculated to be soldered on the PCB.

Return Loss PA26AResults



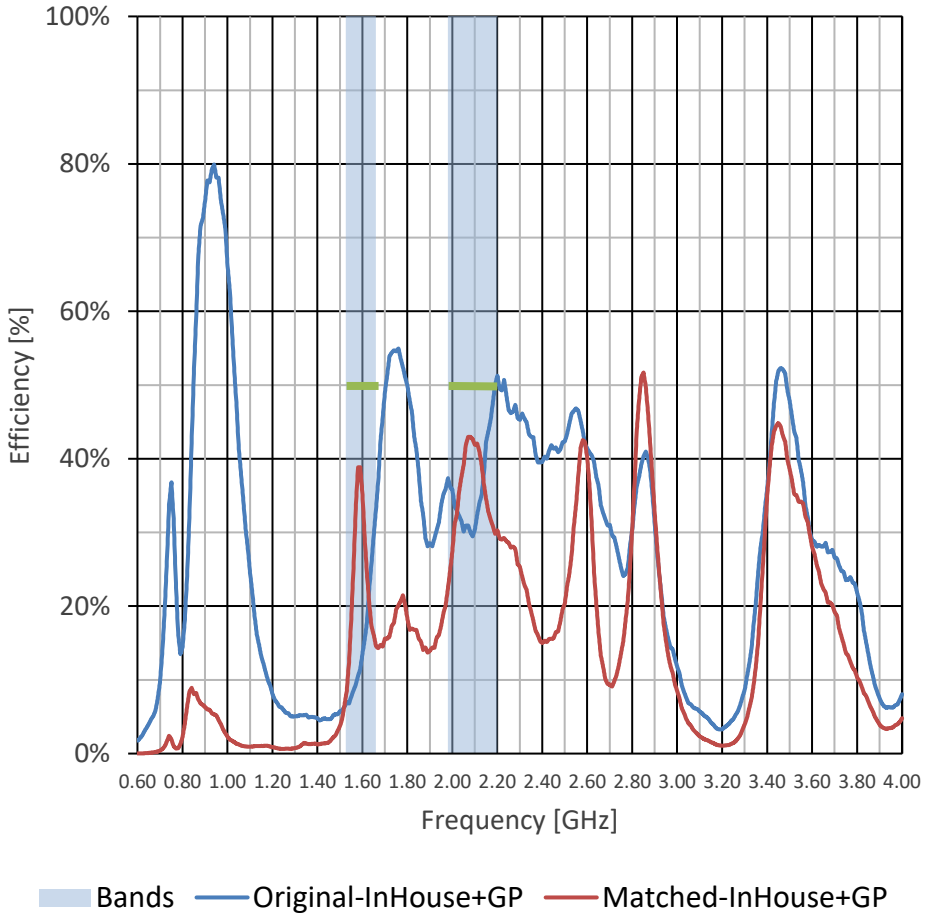
Original



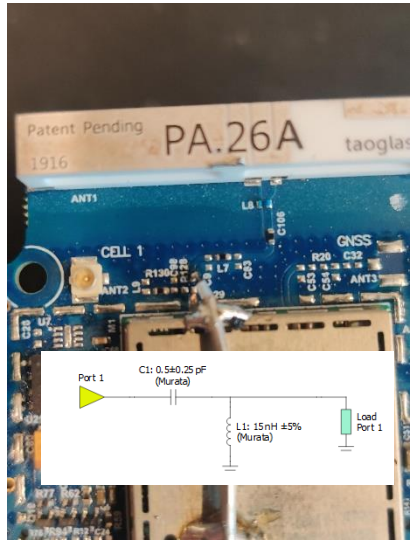
Matched

	Original-InHouse+GP			Matched-InHouse+GP		
Band	Max	Mean	Min	Max	Mean	Min
B255 1525-1660 MHz	-1.7	-3.0	-5.6	-2.4	-8.0	-24.1
B256 1980-2200 MHz	-4.5	-6.4	-10.2	-3.9	-11.1	-25.1
B23 2000-2200 MHz	-4.5	-6.4	-10.2	-5.2	-11.8	-25.1

Efficiency PA26AResults



Original

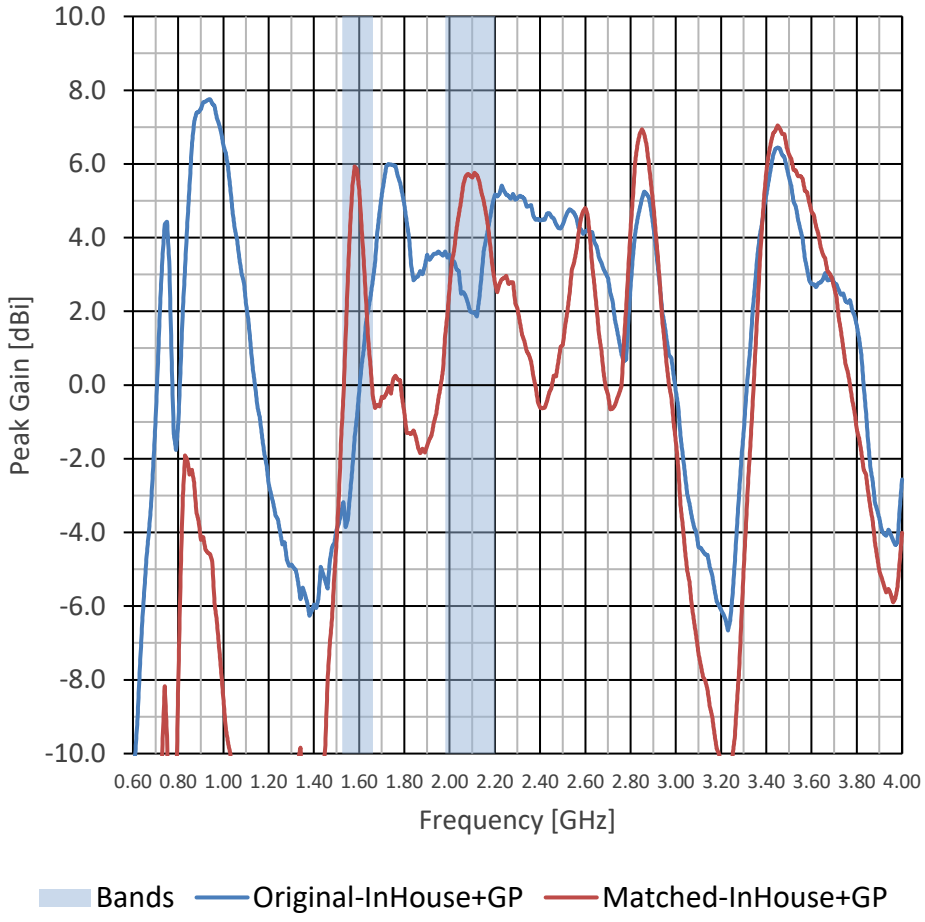


Matched

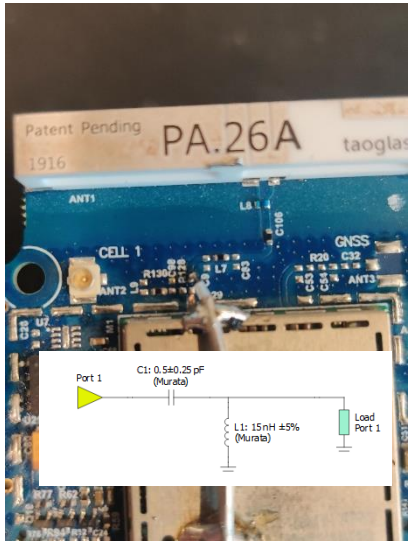
FinalTrace

	Original-InHouse+GP			Matched-InHouse+GP			FinalTrace-InHouse+GP		
Band	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
B255 1525-1660 MHz	33.1	15.6	6.8	38.8	23.7	8.5	58.0	55.2	52.8
B256 1980-2200 MHz	51.3	36.6	29.5	43.0	35.3	22.4	39.5	31.2	17.8
B23 2000-2200 MHz	51.3	36.6	29.5	43.0	36.4	27.5	39.5	32.2	27.2

Peak Gain PA26AResults for Gtotal



Original

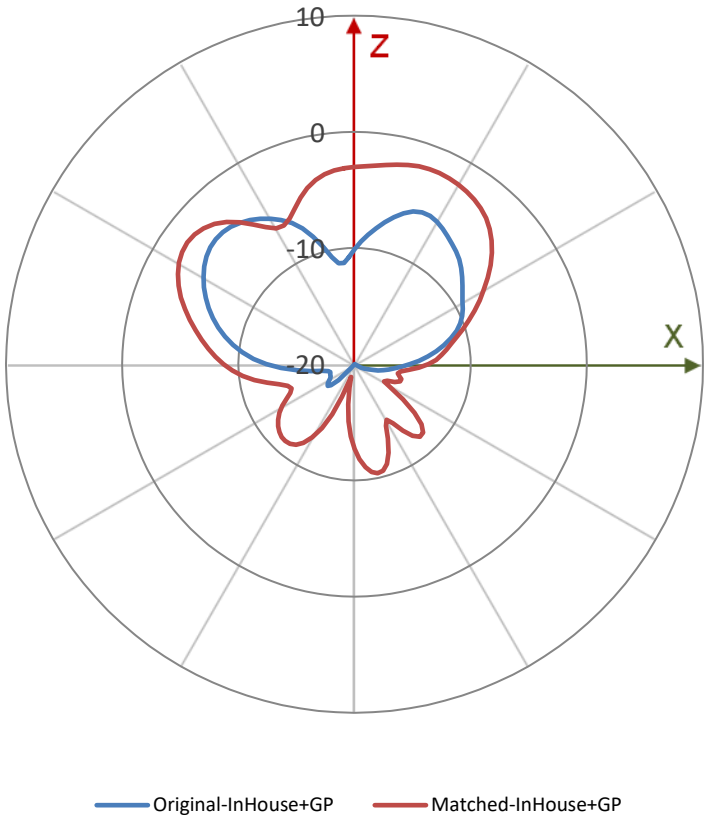


Matched

	Original-InHouse+GP			Matched-InHouse+GP		
Band	Max	Mean	Min	Max	Mean	Min
B255 1525-1660 MHz	2.8	-0.6	-3.9	5.9	3.0	-0.3
B256 1980-2200 MHz	5.2	3.2	1.9	5.8	4.4	1.3
B23 2000-2200 MHz	5.2	3.1	1.9	5.8	4.6	2.7

B255 Radiation Pattern @1592 MHz for [Gtotal]

phi = 0



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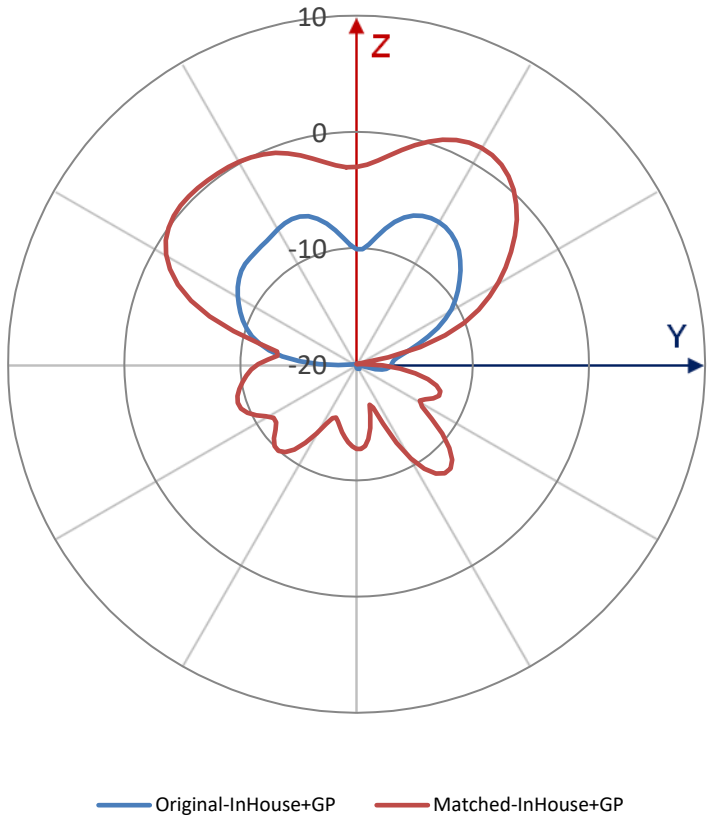

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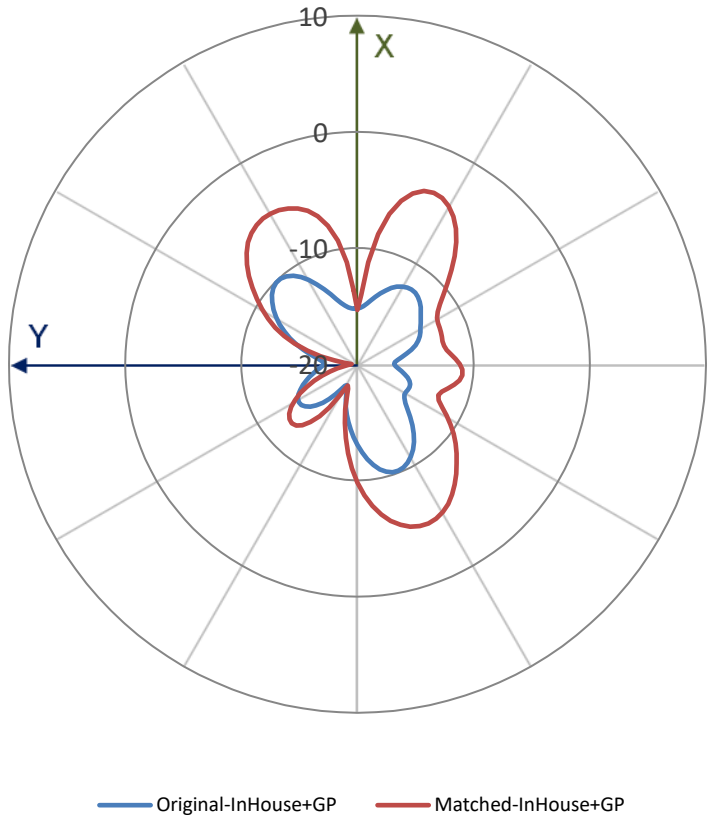
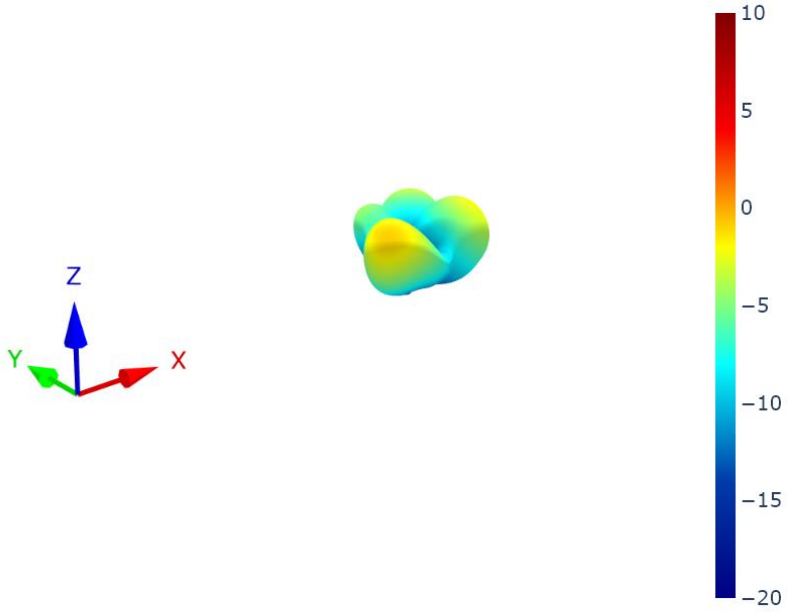
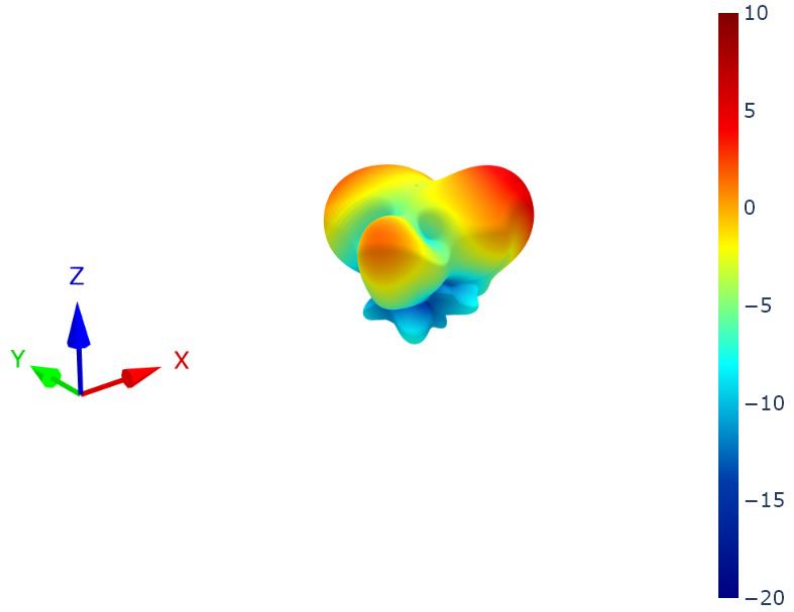


B255 3D Radiation Pattern @1592 MHz [Gtotal]



Original-InHouse+GP



Matched-InHouse+GP

B256 Radiation Pattern @2090 MHz for [Gtotal]

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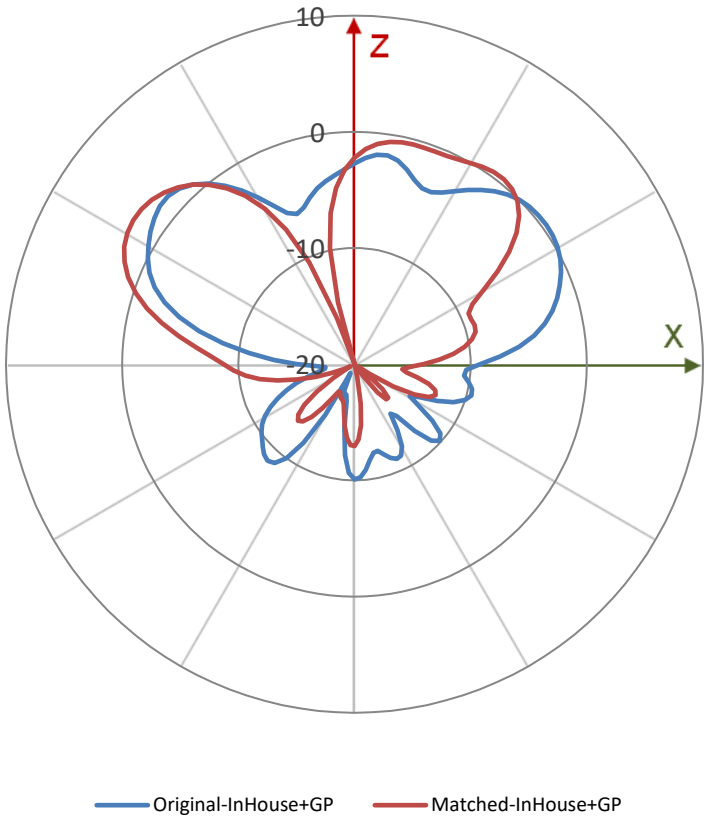

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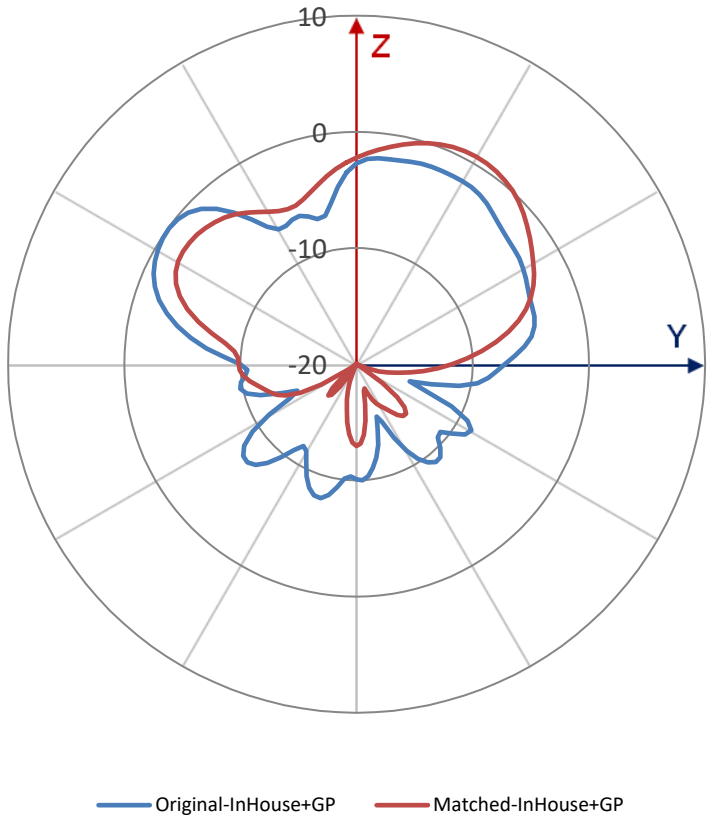

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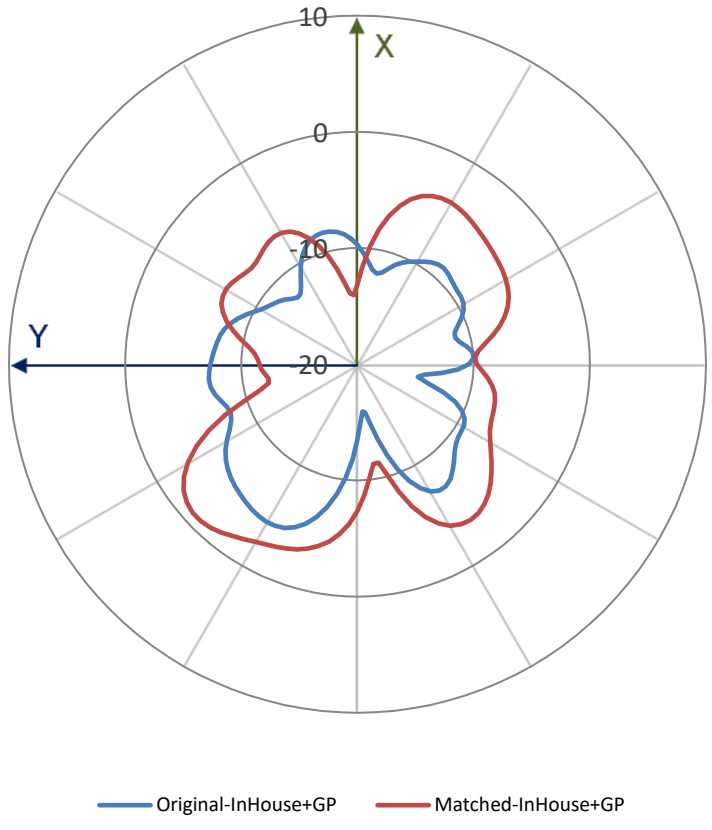
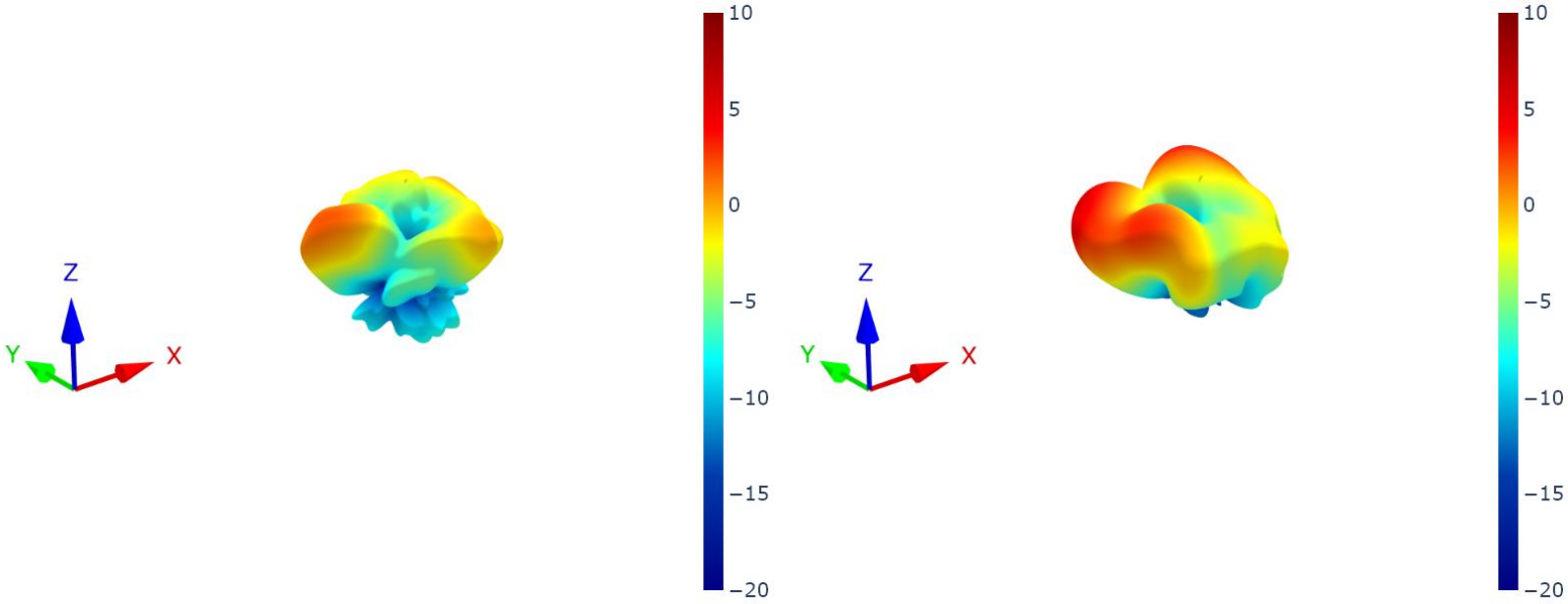


B256 3D Radiation Pattern @2090 MHz [Gtotal]



Original-InHouse+GP

Matched-InHouse+GP

B23 Radiation Pattern @2100 MHz for [Gtotal]

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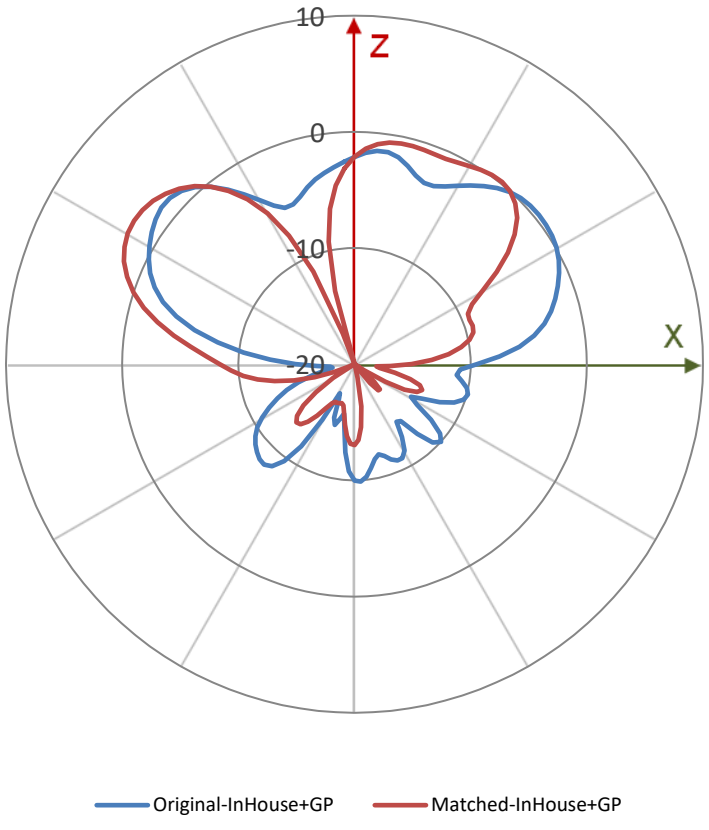

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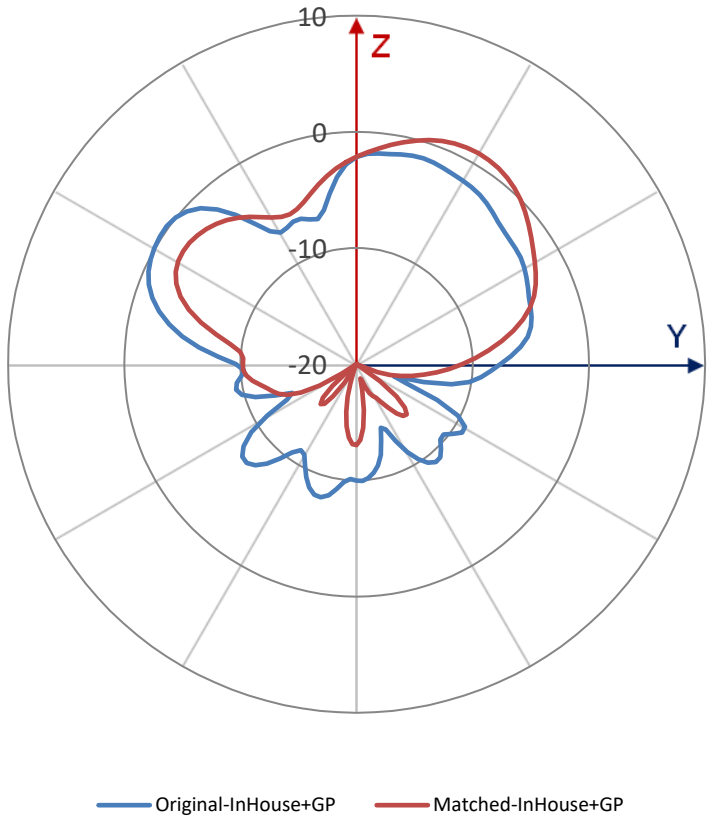

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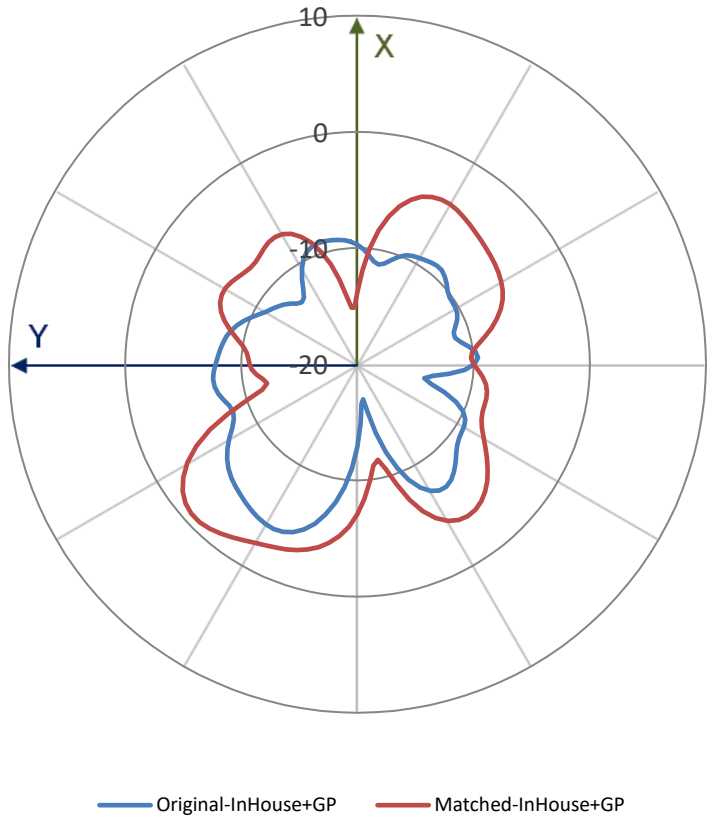
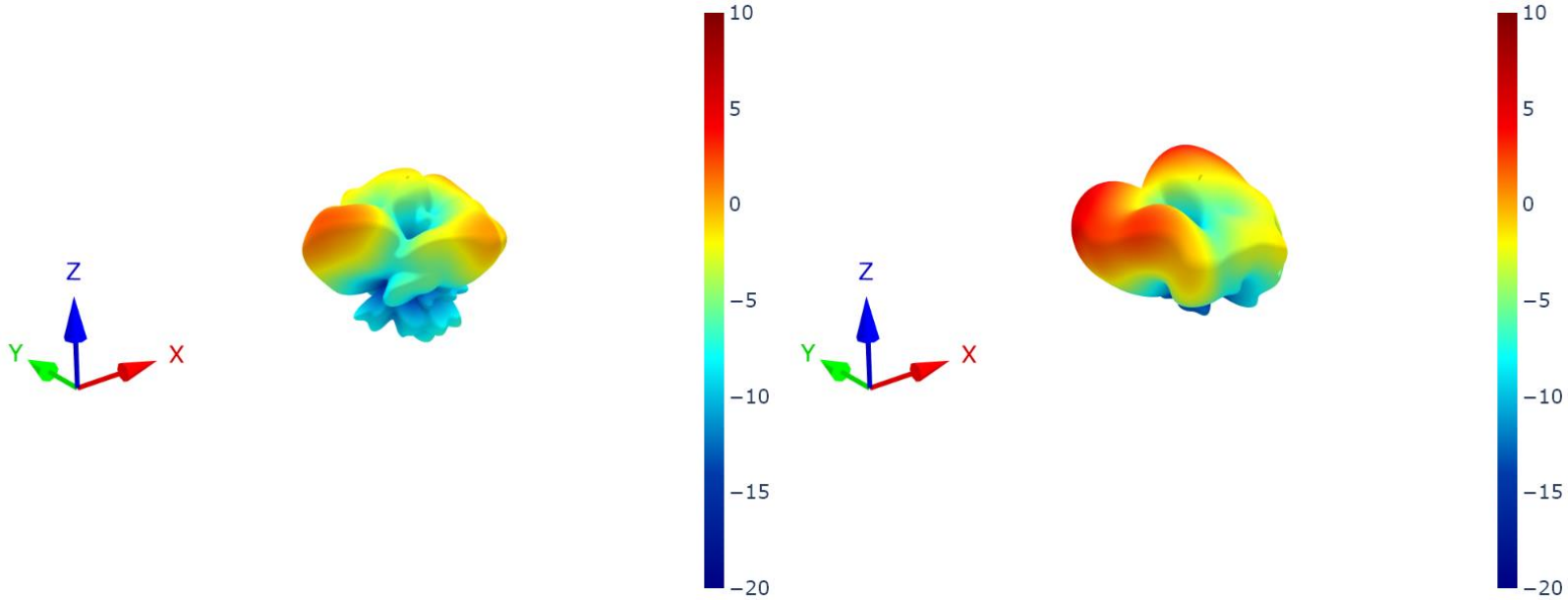


B23 3D Radiation Pattern @2100 MHz [Gtotal]



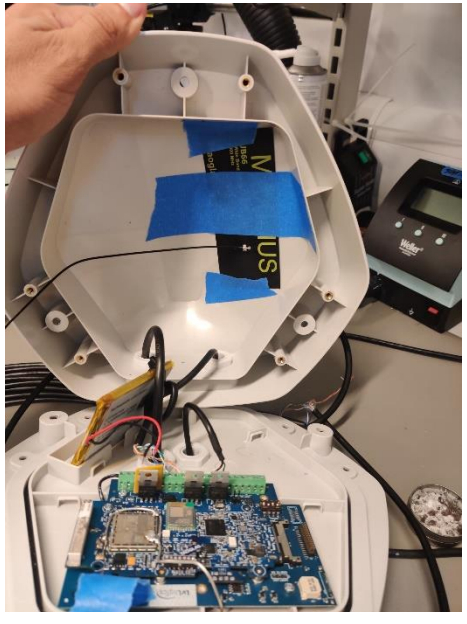
Original-InHouse+GP

Matched-InHouse+GP

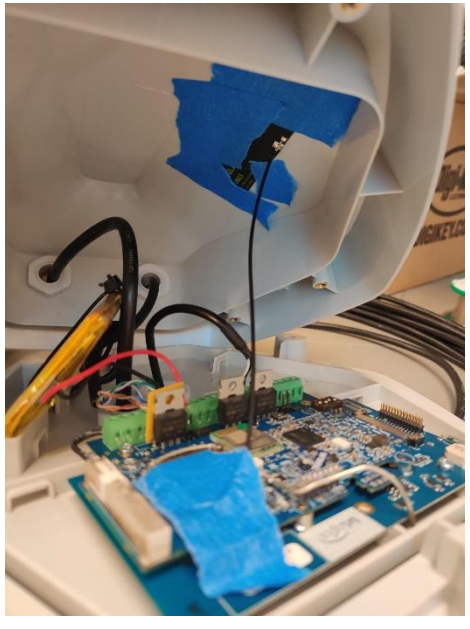
Cellular Flex Antennas

Overview - SiloSpi Device - Tested Flex Antennas

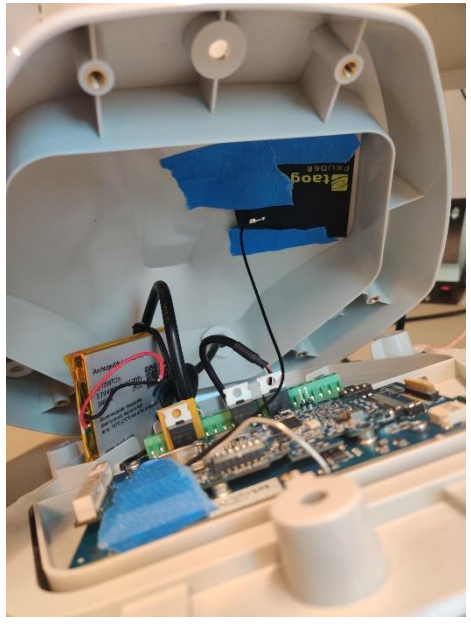
- Multiple flexible antennas have been stuck on the top shell of the device



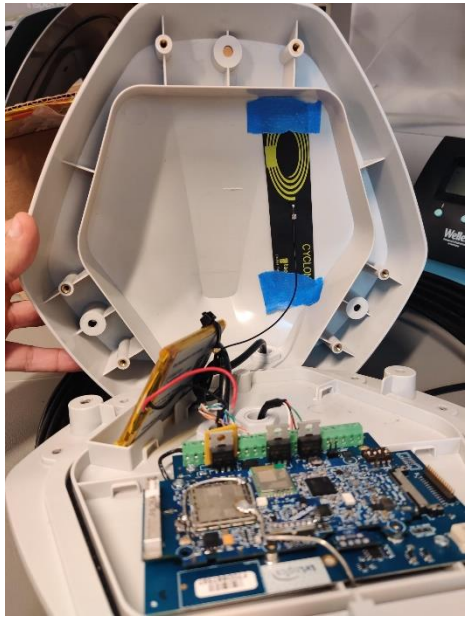
FXUB66



FXUB63



FXUB68-65



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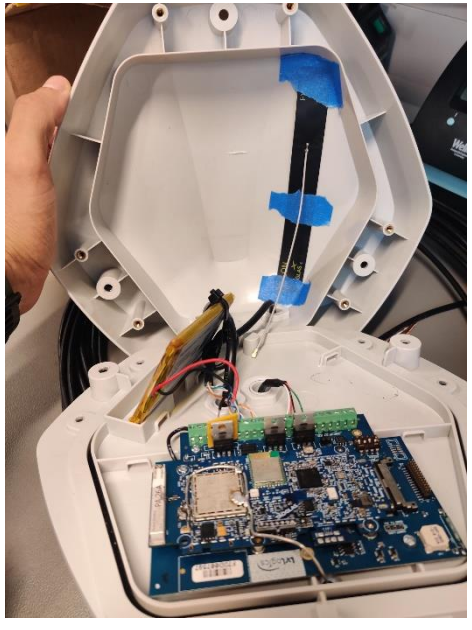
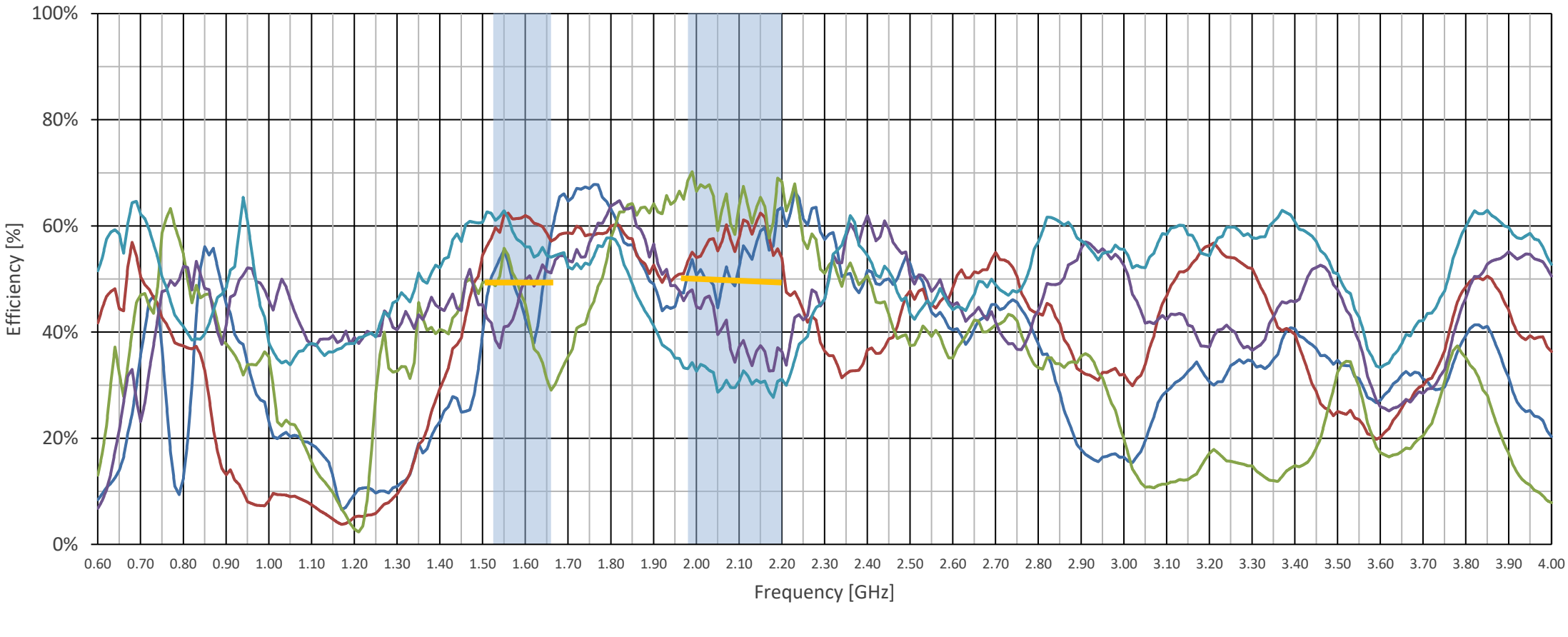


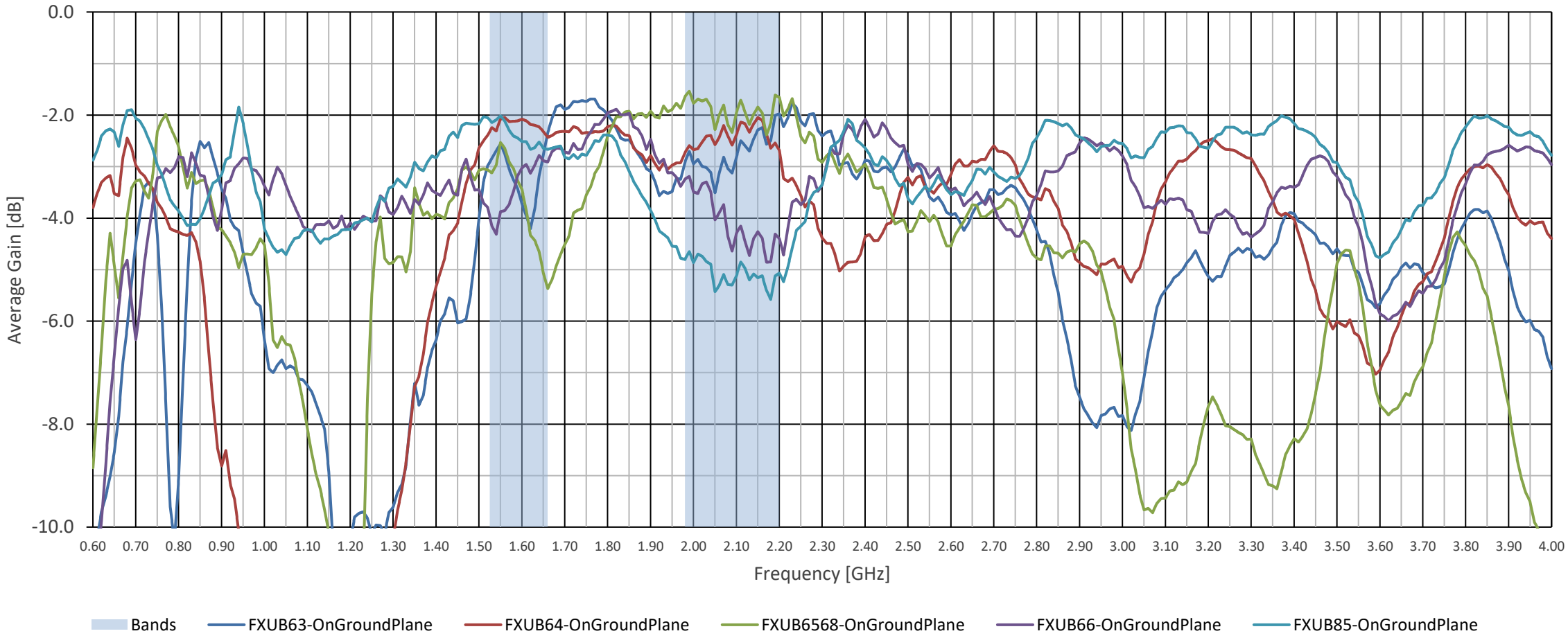
FXUB85

Efficiency Skylo-FlexAntennas-OnGround



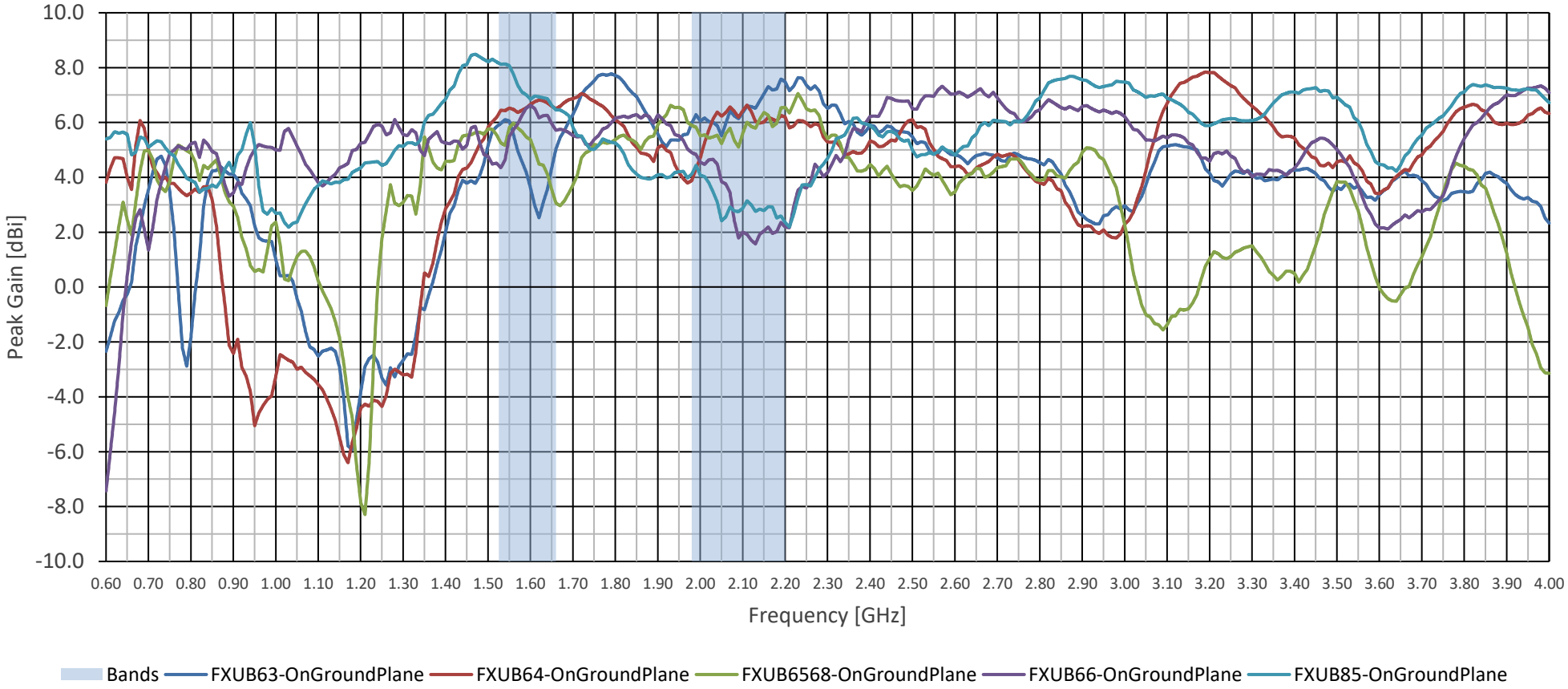
	FXUB63-OnGroundPlane			FXUB64-OnGroundPlane			FXUB6568-OnGroundPlane			FXUB66-OnGroundPlane			FXUB85-OnGroundPlane		
Band	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
Band 255 1525-1660 MHz	58.3	48.4	37.9	62.4	60.5	57.1	55.8	43.7	29.1	52.7	46.3	37.0	62.9	57.6	54.1
Band 256															

Average Gain Skylo-FlexAntennas-OnGround



	FXUB63-OnGroundPlane			FXUB64-OnGroundPlane			FXUB6568-OnGroundPlane			FXUB66-OnGroundPlane			FXUB85-OnGroundPlane		
Band	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
Band 255 1525-1660 MHz	-2.3	-3.2	-4.2	-2.0	-2.2	-2.4	-2.5	-3.7	-5.4	-2.8	-3.4	-4.3	-2.0	-2.4	-2.7

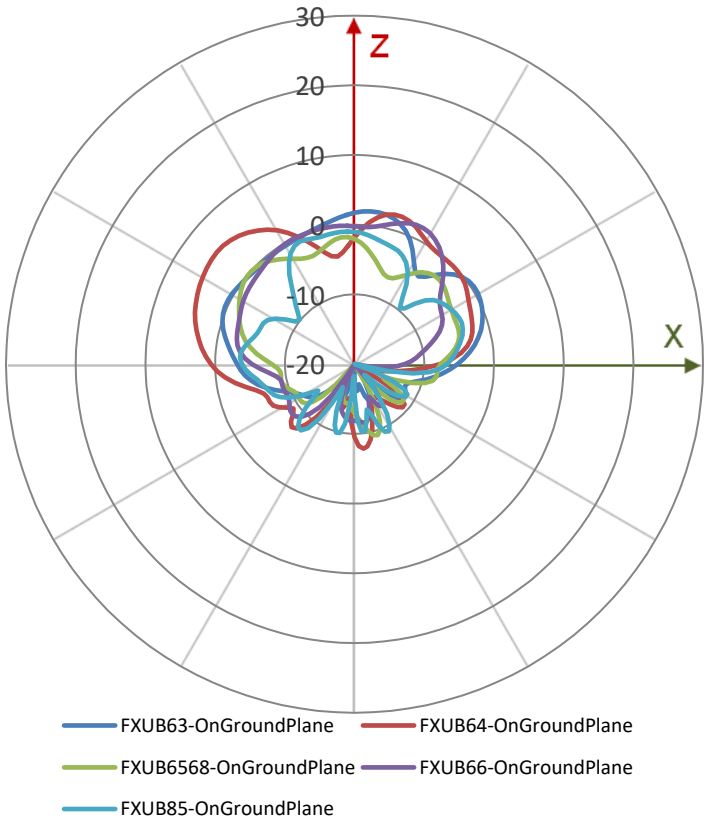
Peak Gain Skylo-FlexAntennas-OnGround for Gtotal



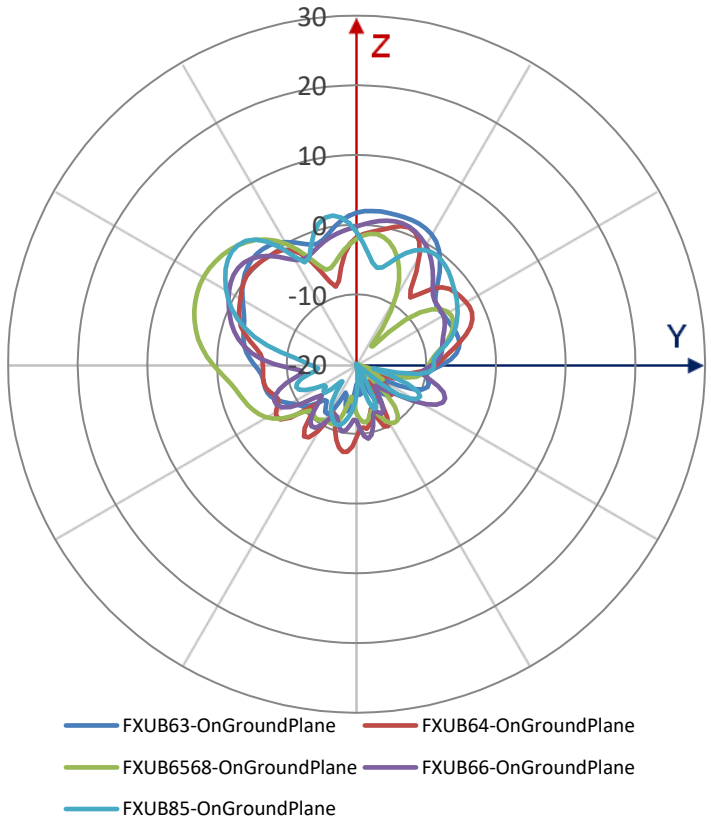
	FXUB63-OnGroundPlane			FXUB64-OnGroundPlane			FXUB6568-OnGroundPlane			FXUB66-OnGroundPlane			FXUB85-OnGroundPlane		
Band	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
Band 255 1525-1660 MHz	6.1	4.5	2.5	6.8	6.6	6.4	6.0	4.9	3.1	6.6	5.9	4.3	8.1	7.2	6.5
Band 256 1980-2200 MHz	7.6	6.5	5.5	6.6	5.9	3.9	6.6	5.8	5.1	4.9	3.0	1.6	4.4	3.1	2.4

Band 255 Radiation Pattern @1592 MHz for [Gtotal]

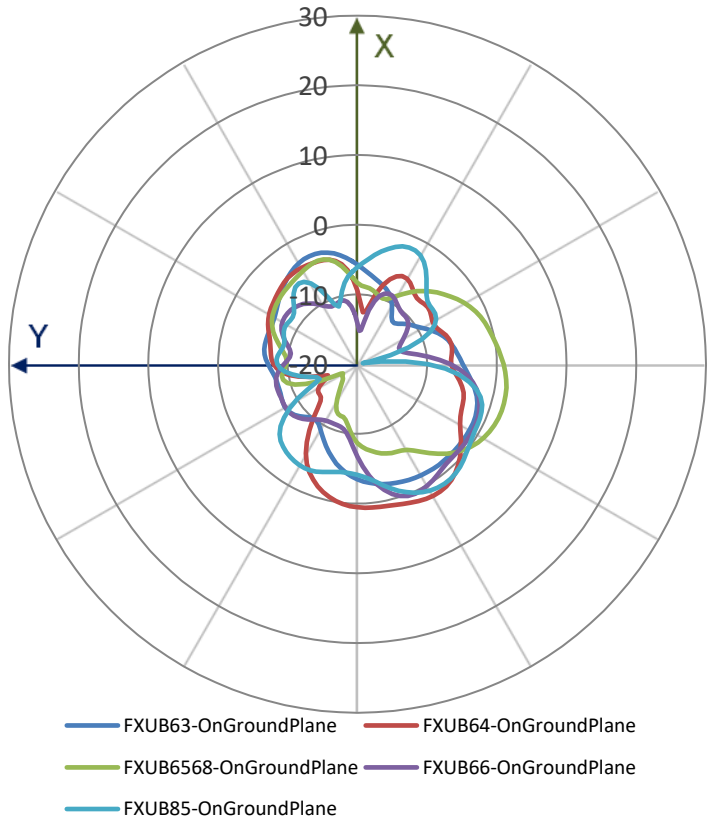
phi = 0



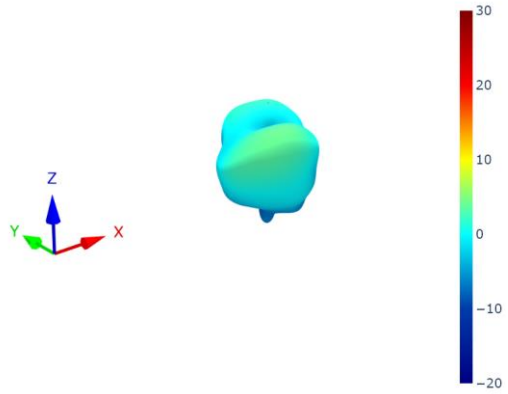
phi = 90



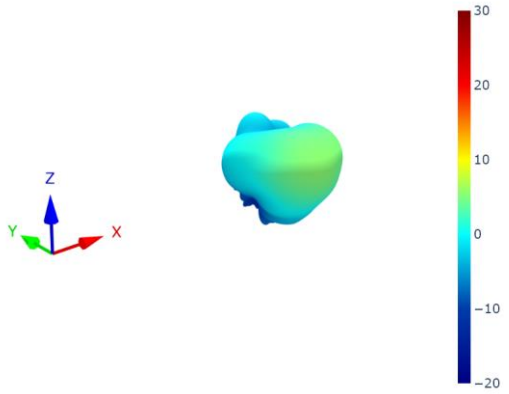
theta = 90



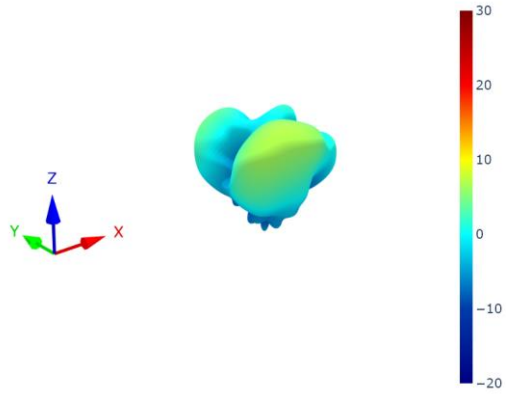
Band 255 3D Radiation Pattern @1592 MHz [Gtotal]



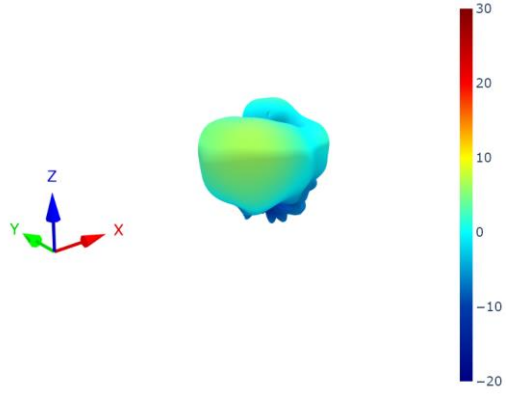
FXUB63-OnGroundPlane



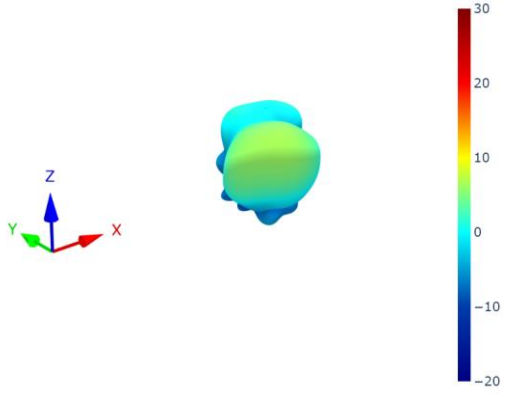
FXUB6568-OnGroundPlane



FXUB85-OnGroundPlane



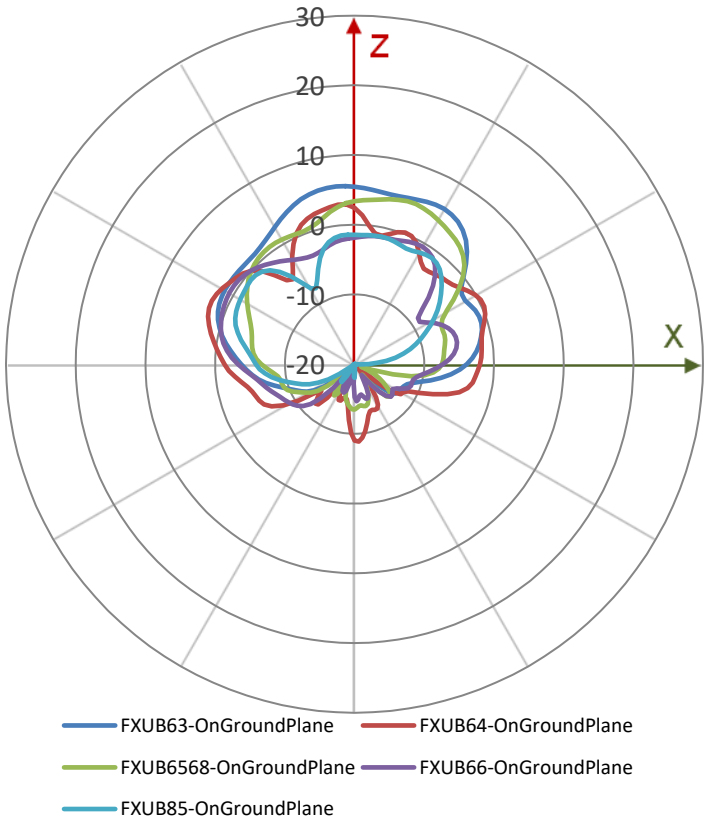
FXUB64-OnGroundPlane



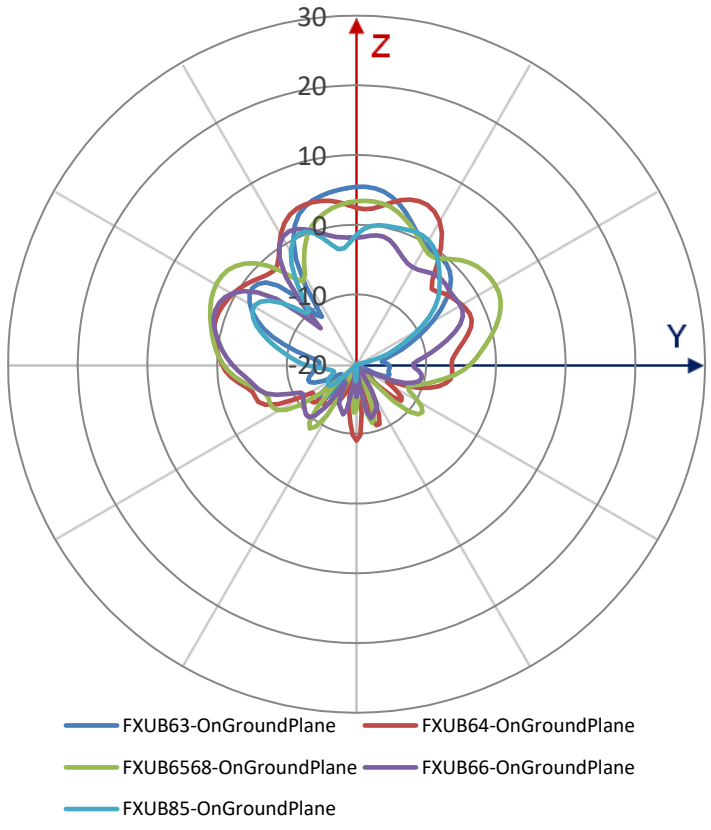
FXUB66-OnGroundPlane

Band 256 Radiation Pattern @2090 MHz for [Gtotal]

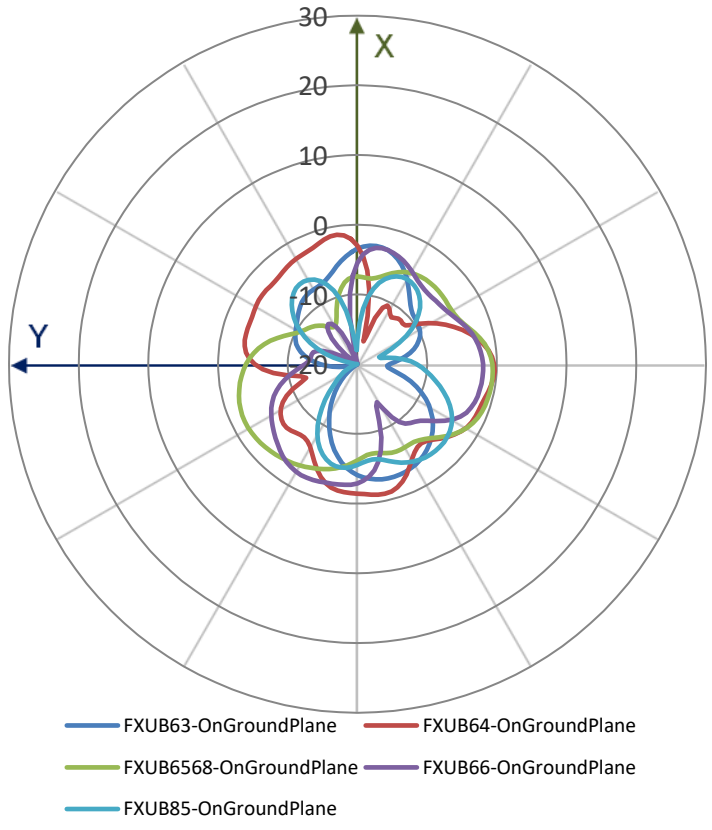
phi = 0



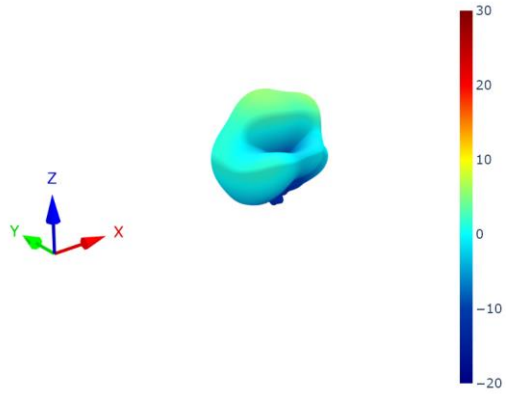
phi = 90



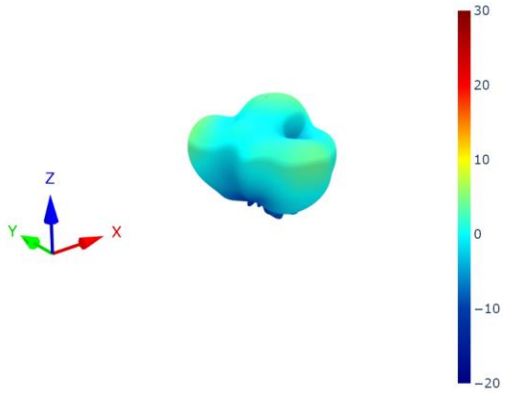
theta = 90



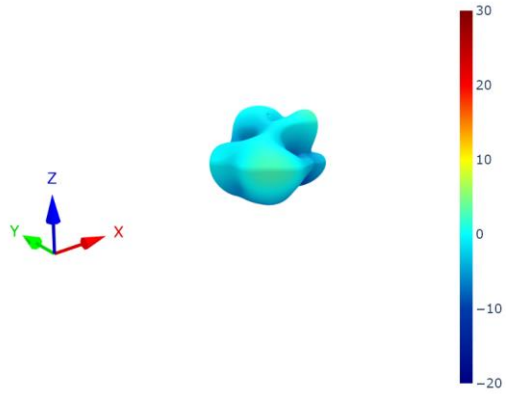
Band 256 3D Radiation Pattern @2090 MHz [Gtotal]



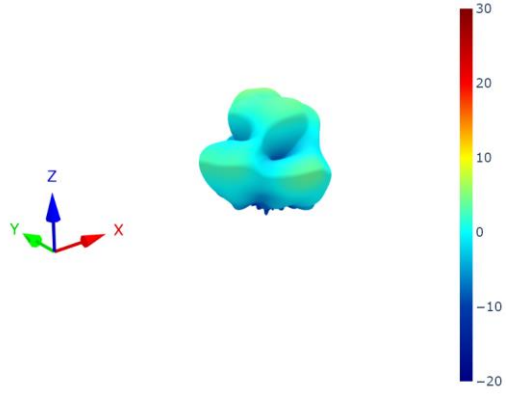
FXUB63-OnGroundPlane



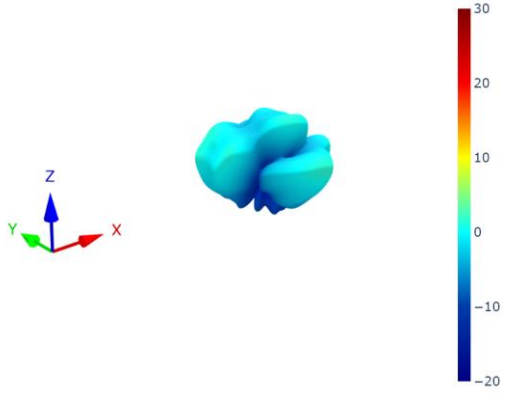
FXUB6568-OnGroundPlane



FXUB85-OnGroundPlane



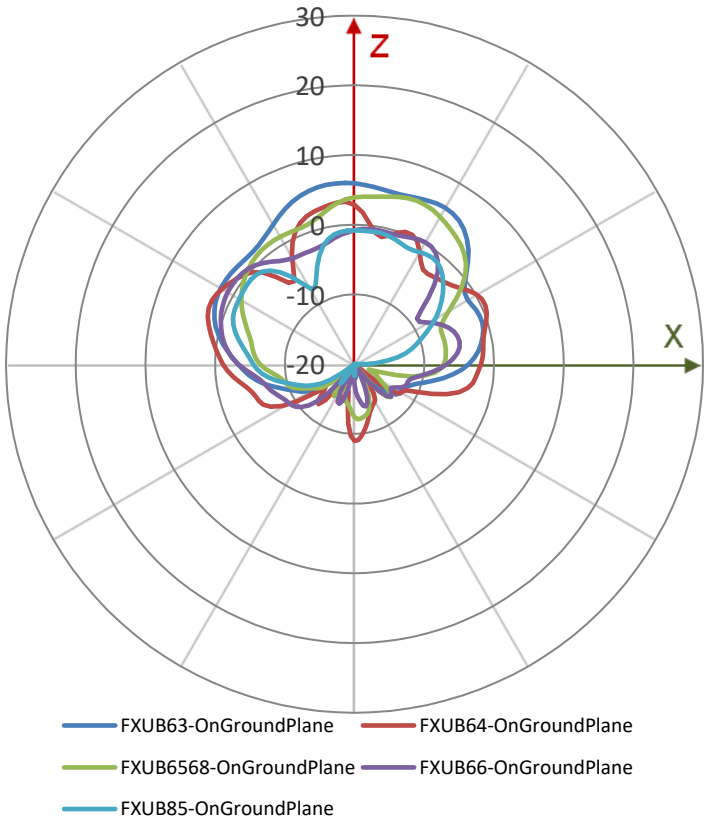
FXUB64-OnGroundPlane



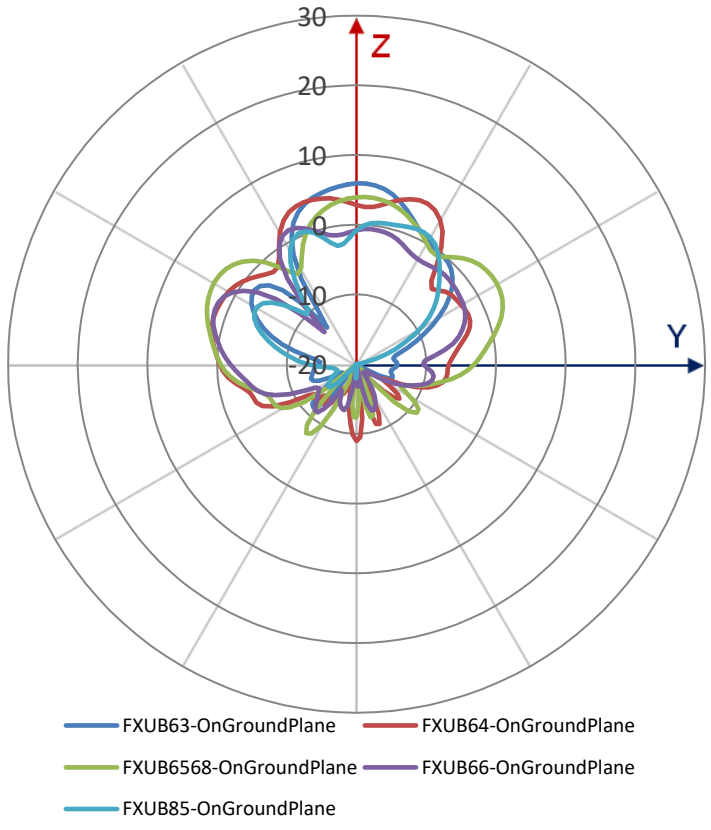
FXUB66-OnGroundPlane

Band 23 Radiation Pattern @2100 MHz for [Gtotal]

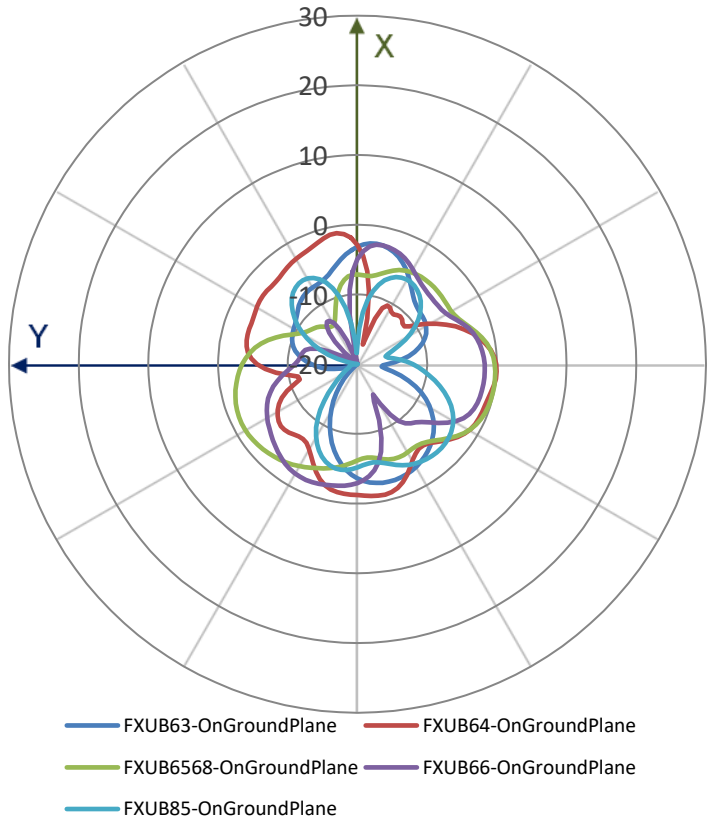
phi = 0



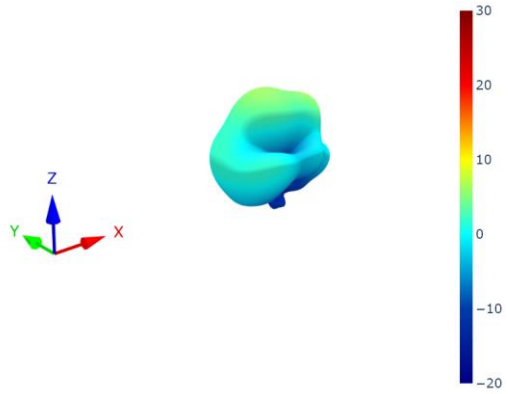
phi = 90



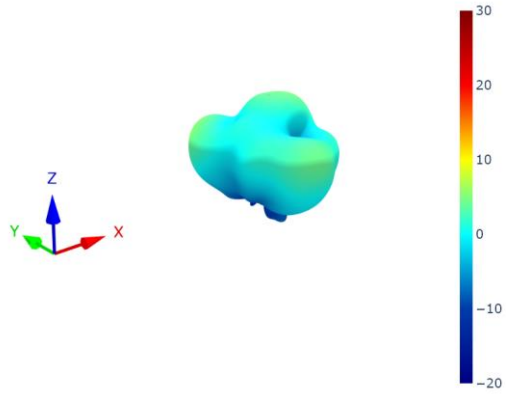
theta = 90



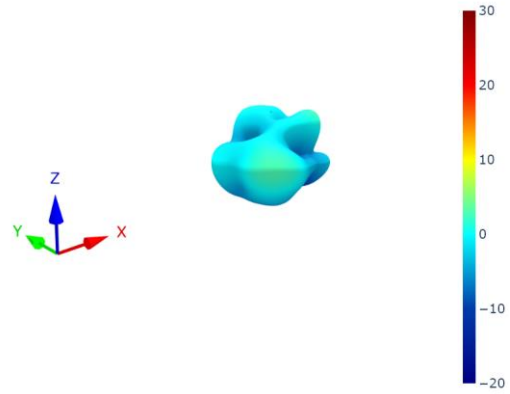
Band 23 3D Radiation Pattern @2100 MHz [Gtotal]



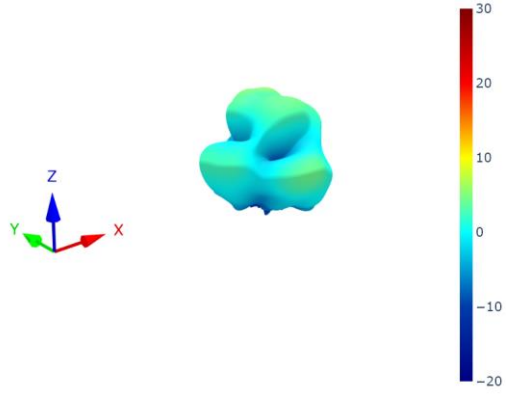
FXUB63-OnGroundPlane



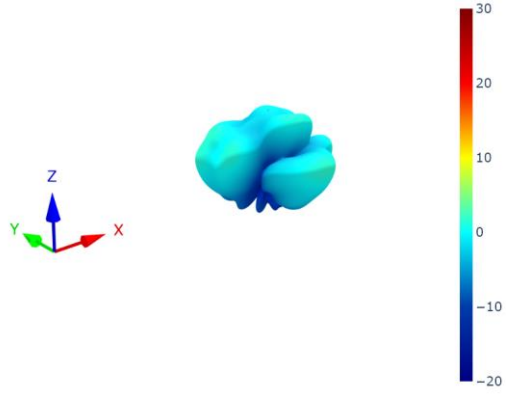
FXUB6568-OnGroundPlane



FXUB85-OnGroundPlane



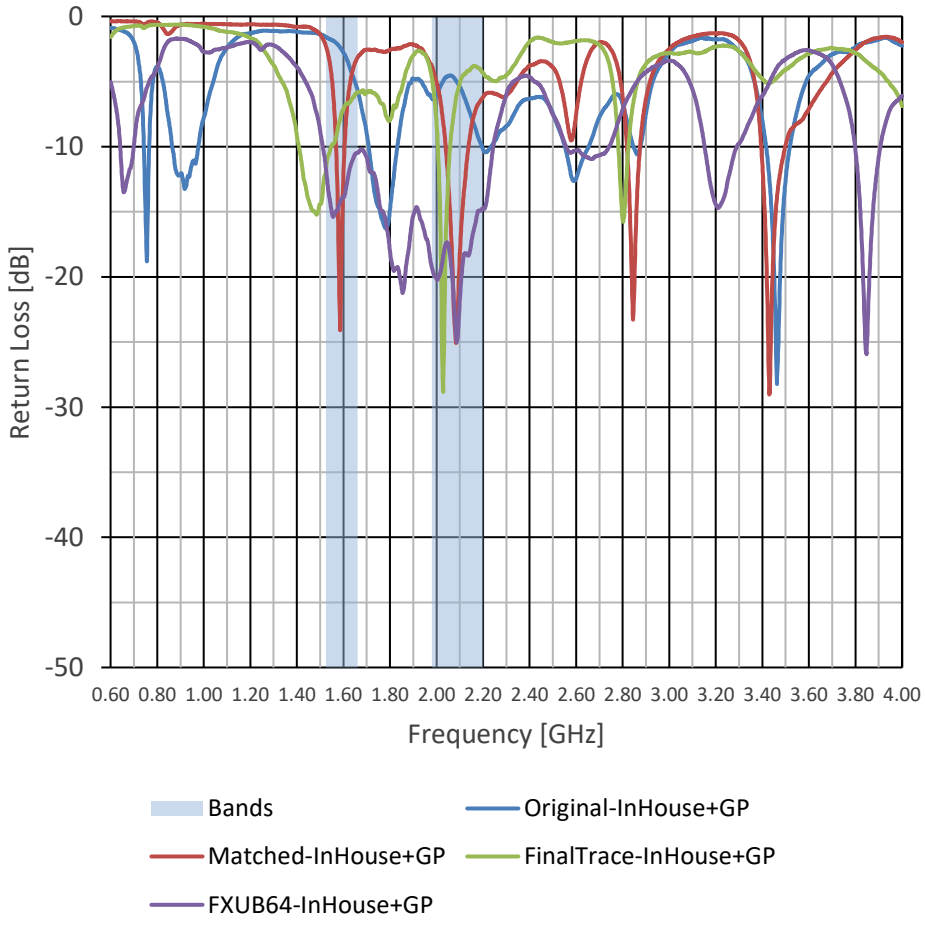
FXUB64-OnGroundPlane



FXUB66-OnGroundPlane

FinalComparison

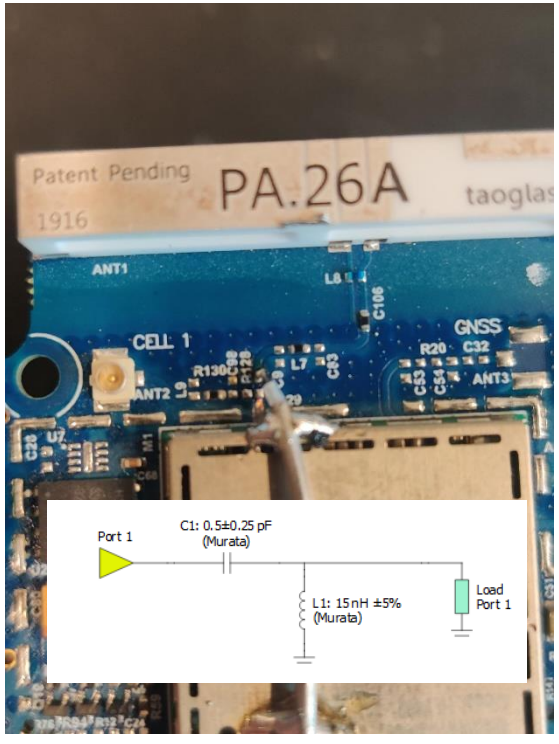
Return Loss FinalComparison



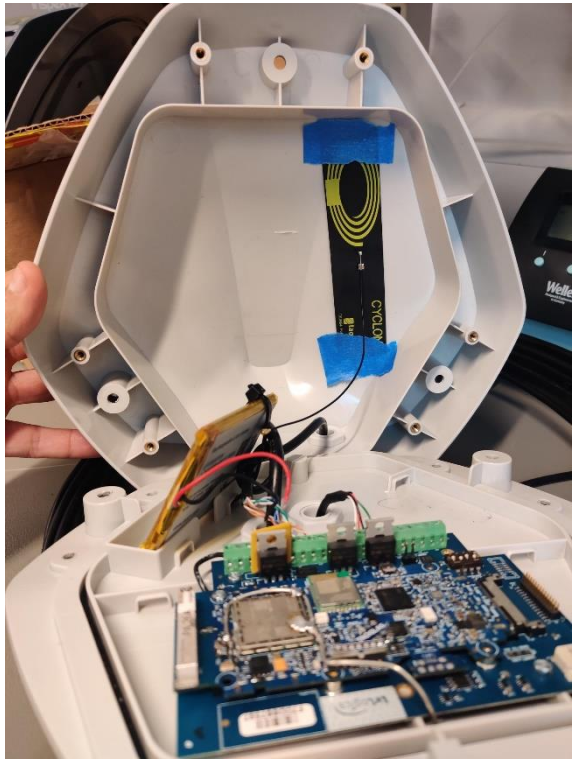
	Original-InHouse+GP			Matched-InHouse+GP			FinalTrace-InHouse+GP			FXUB64-InHouse+GP		
Band	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
B255 1525-1660 MHz	-1.7	-3.0	-5.6	-2.4	-8.0	-24.1	-5.8	-8.0	-11.4	-10.5	-13.2	-15.4
B256 1980-2200 MHz	-4.5	-6.4	-10.2	-3.9	-11.1	-25.1	-3.8	-8.2	-28.8	-14.7	-18.7	-25.0
B23 2000-2200 MHz	-4.5	-6.4	-10.2	-5.2	-11.8	-25.1	-3.8	-8.4	-28.8	-14.7	-18.6	-25.0

Analysed antennas Final Comparison

PA.26A Original

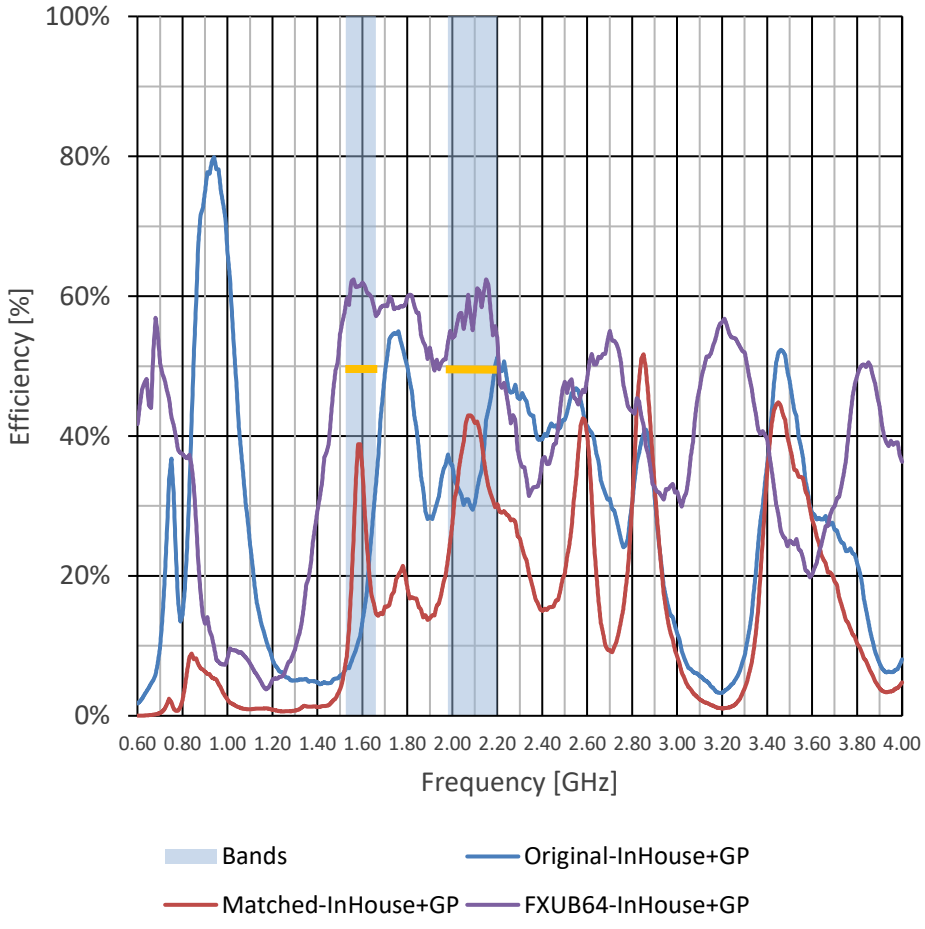


PA.26A Matched



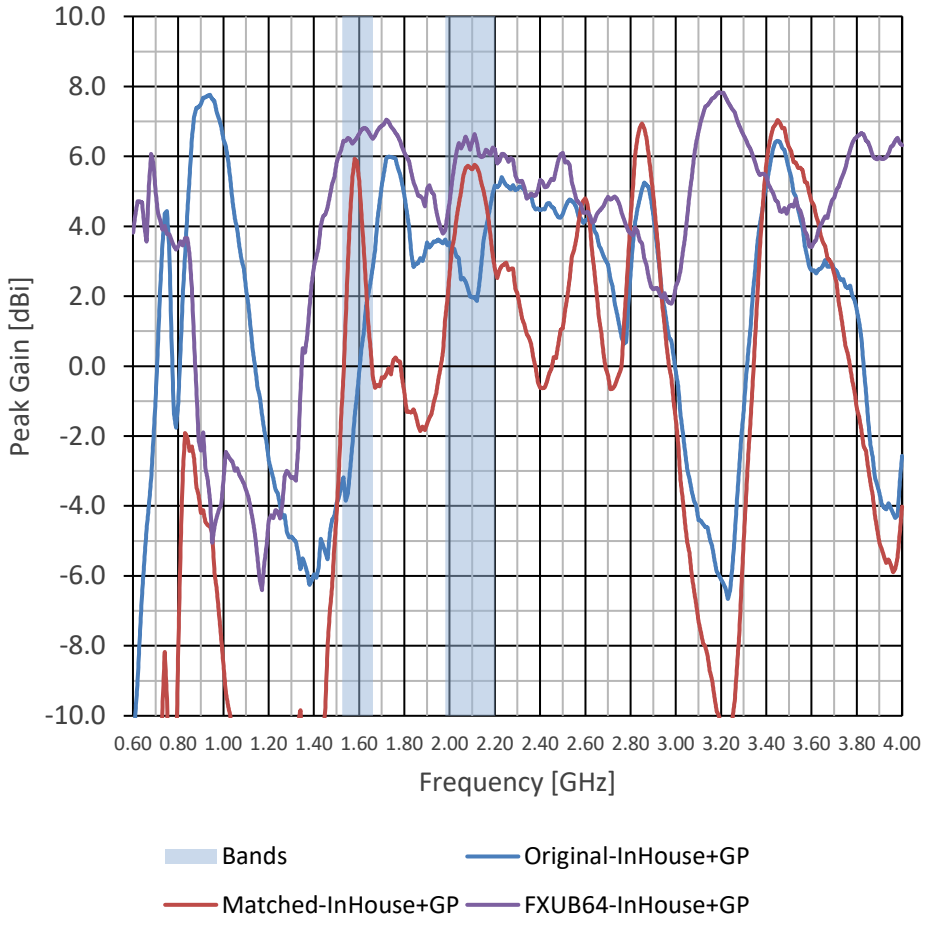
FXUB64

Efficiency FinalComparison



	Original-InHouse+GP			Matched-InHouse+GP			FXUB64-InHouse+GP		
Band	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
B255 1525-1660 MHz	33.1	15.6	6.8	38.8	23.7	8.5	62.4	60.5	57.1
B256 1980-2200 MHz	51.3	36.6	29.5	43.0	35.3	22.4	62.4	57.3	53.3
B23 2000-2200 MHz	51.3	36.6	29.5	43.0	36.4	27.5	62.4	57.6	53.9

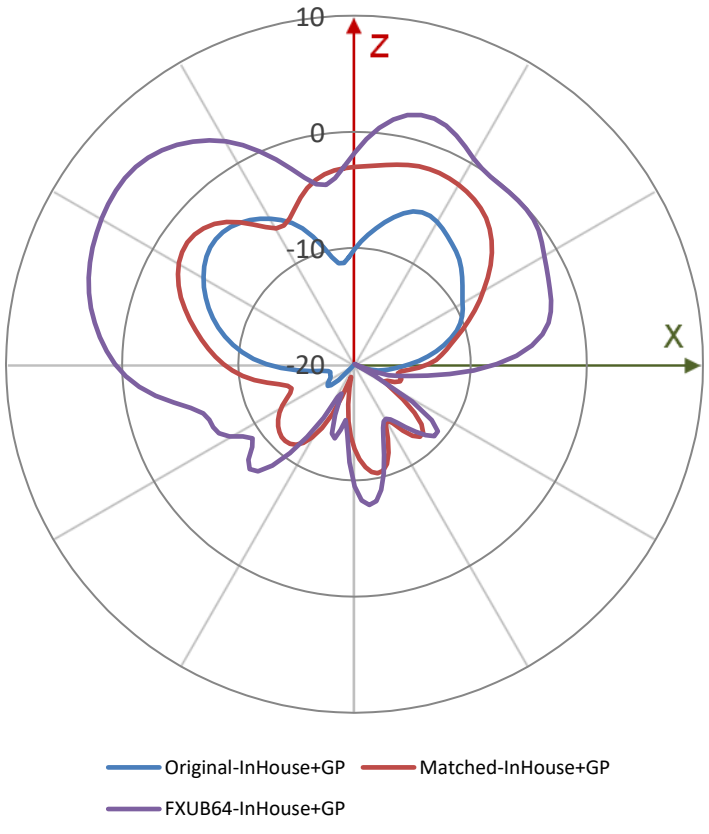
Peak Gain FinalComparison for Gtotal



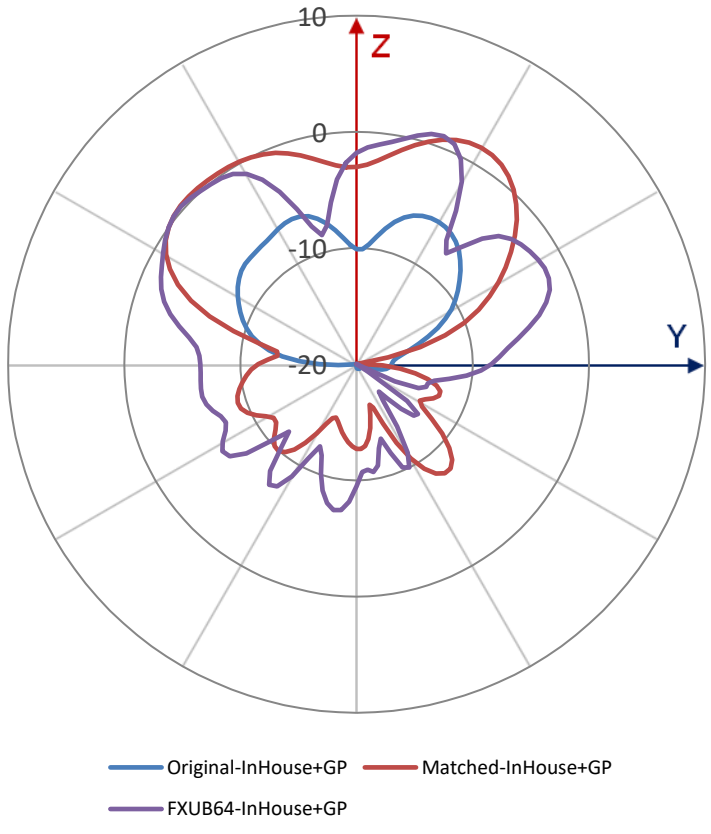
	Original-InHouse+GP			Matched-InHouse+GP			FXUB64-InHouse+GP		
Band	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
B255 1525-1660 MHz	2.8	-0.6	-3.9	5.9	3.0	-0.3	6.8	6.6	6.4
B256 1980-2200 MHz	5.2	3.2	1.9	5.8	4.4	1.3	6.6	5.9	3.9
B23 2000-2200 MHz	5.2	3.1	1.9	5.8	4.6	2.7	6.6	6.1	4.7

B255 Radiation Pattern @1592 MHz for [Gtotal]

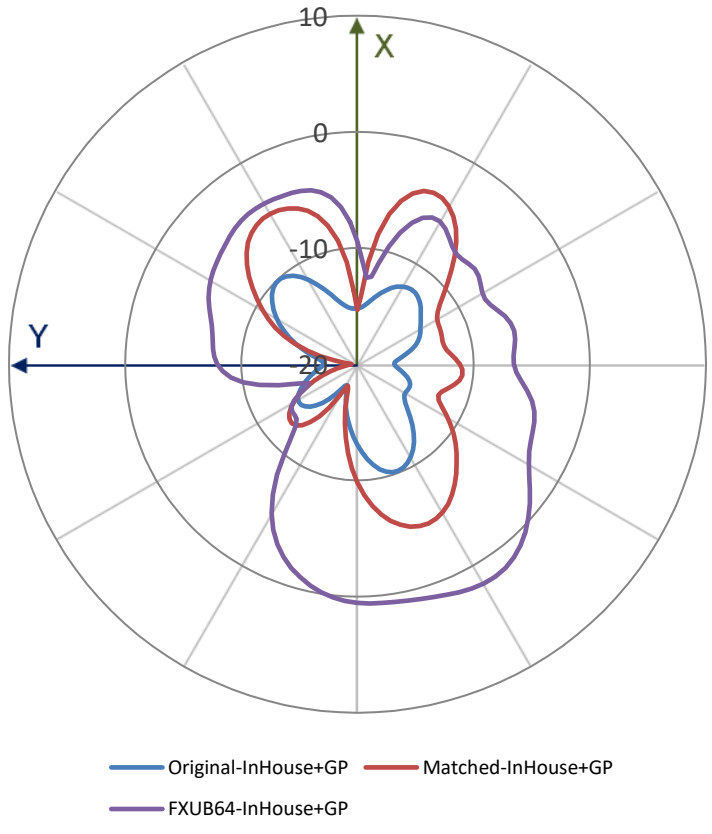
phi = 0



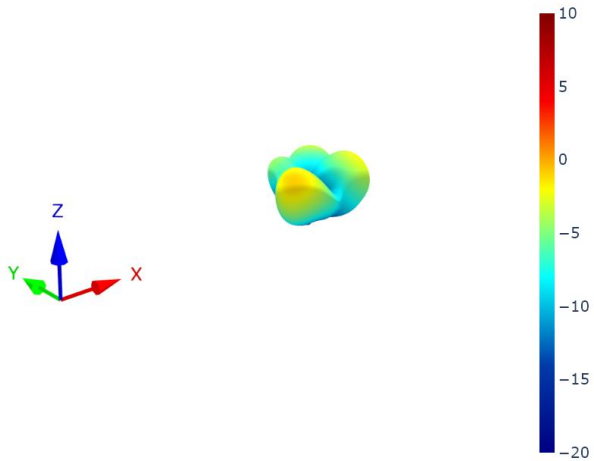
phi = 90



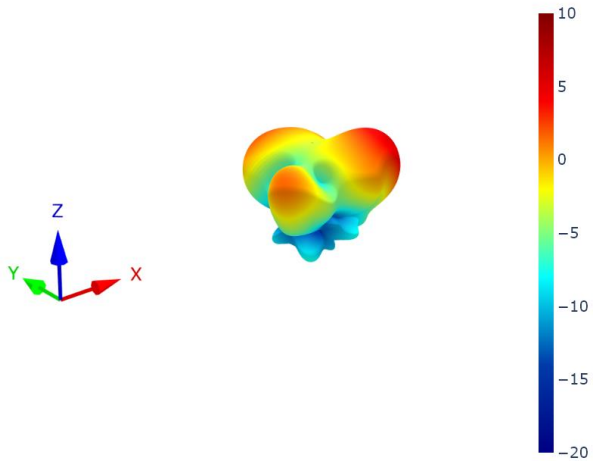
theta = 90



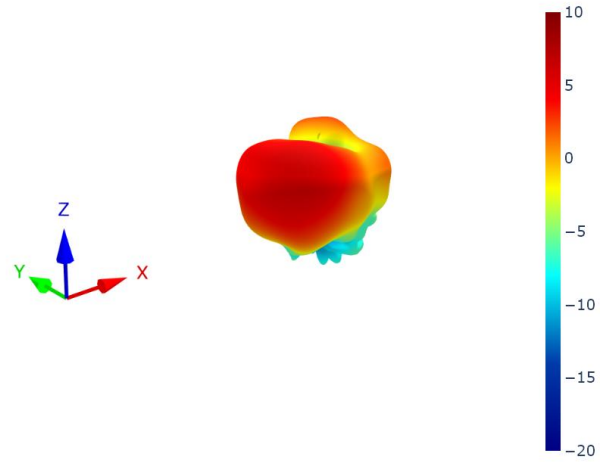
B255 3D Radiation Pattern @1592 MHz [Gtotal]



Original-InHouse+GP



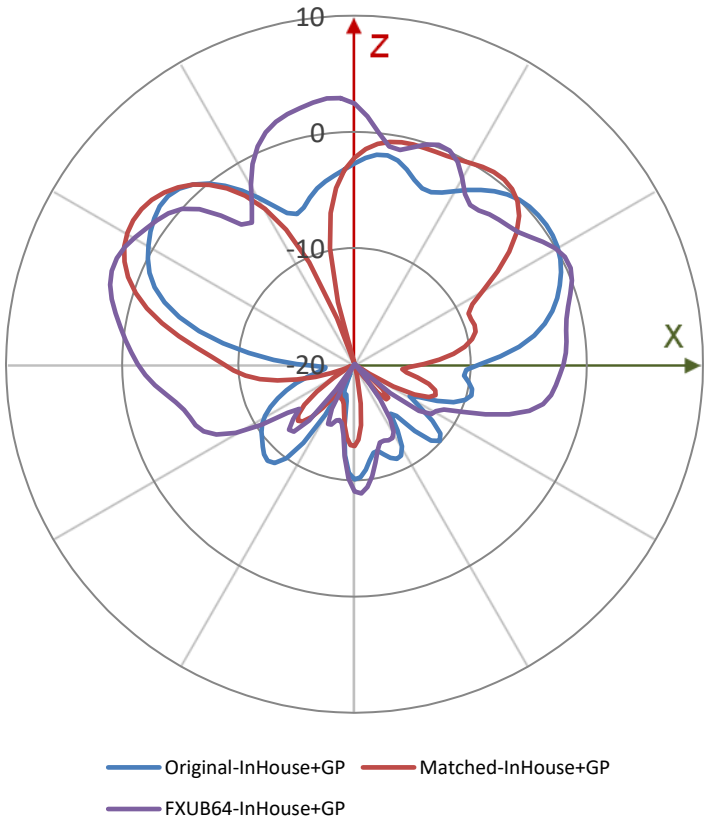
Matched-InHouse+GP



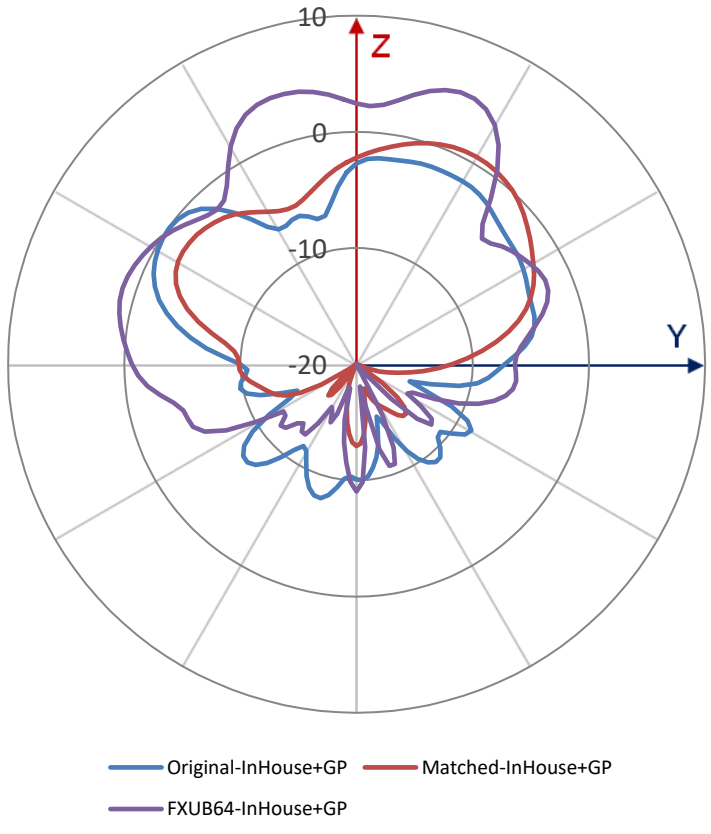
FXUB64-InHouse+GP

B256 Radiation Pattern @2090 MHz for [Gtotal]

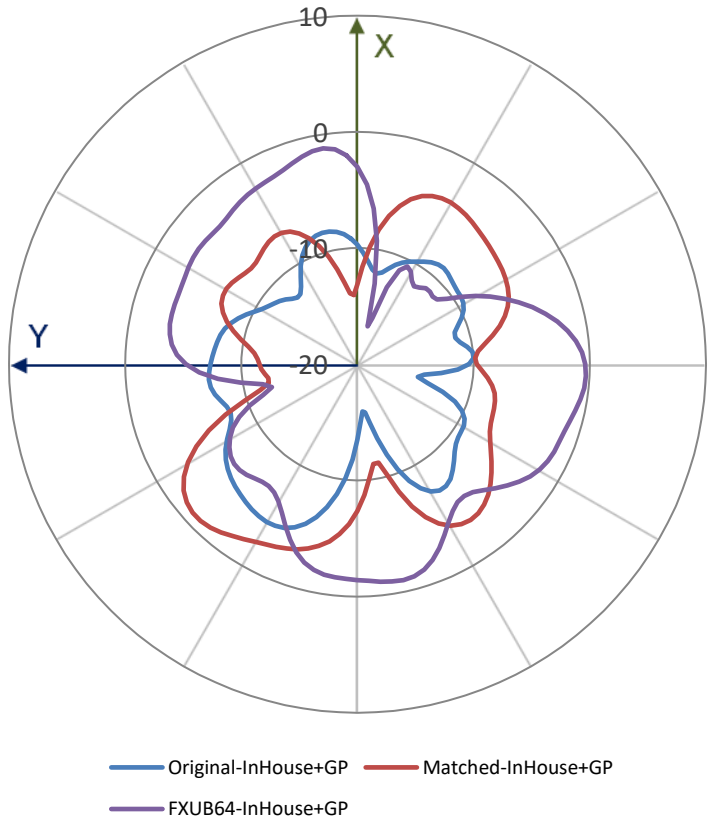
phi = 0



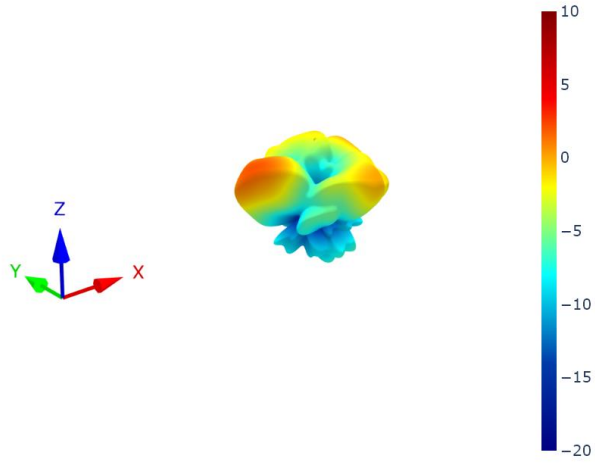
phi = 90



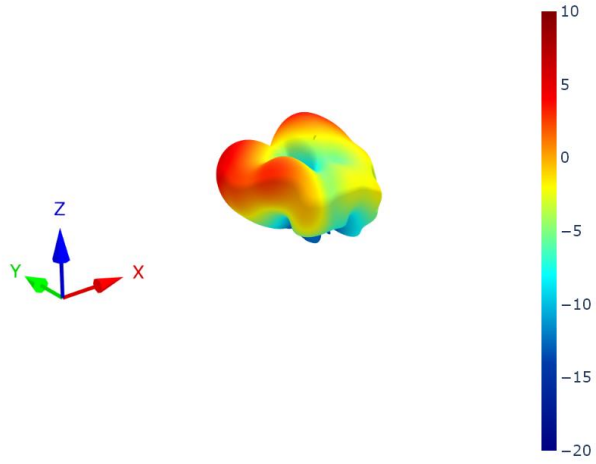
theta = 90



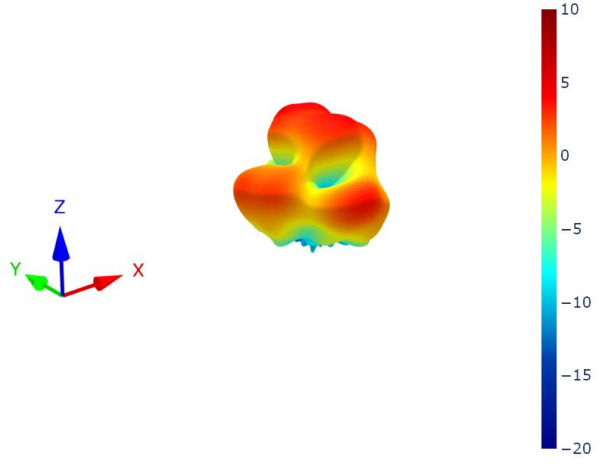
B256 3D Radiation Pattern @2090 MHz [Gtotal]



Original-InHouse+GP



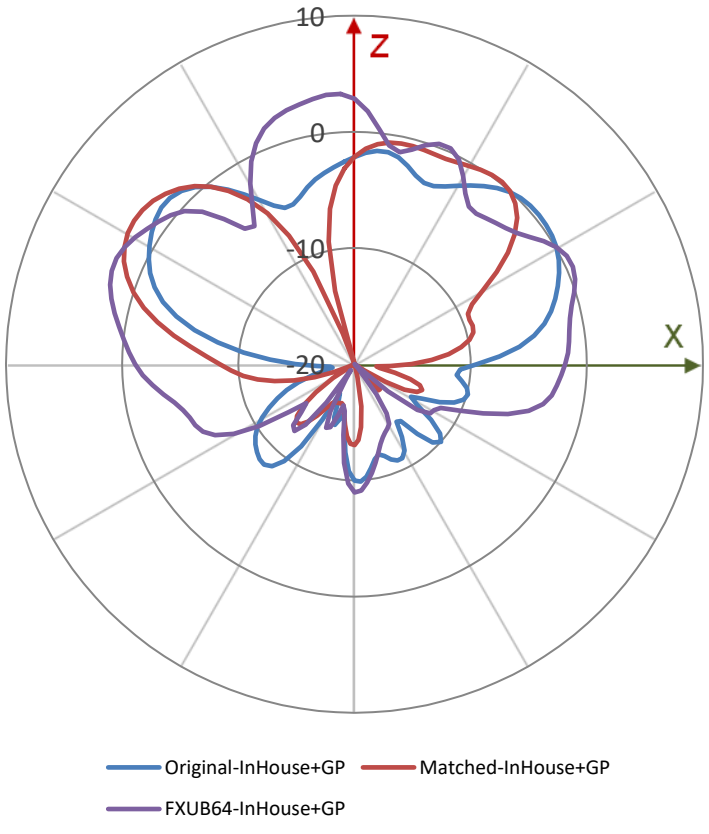
Matched-InHouse+GP



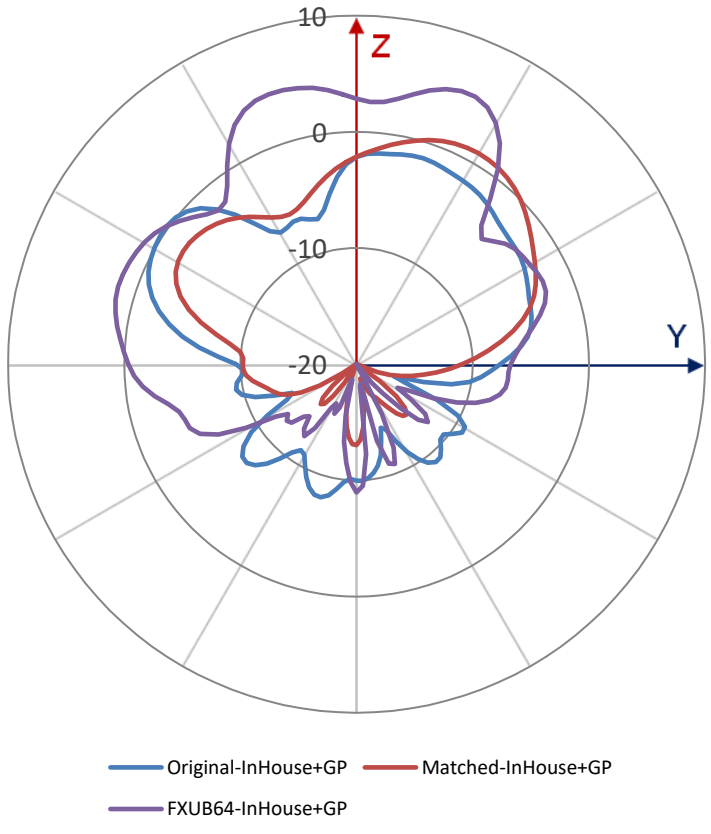
FXUB64-InHouse+GP

B23 Radiation Pattern @2100 MHz for [Gtotal]

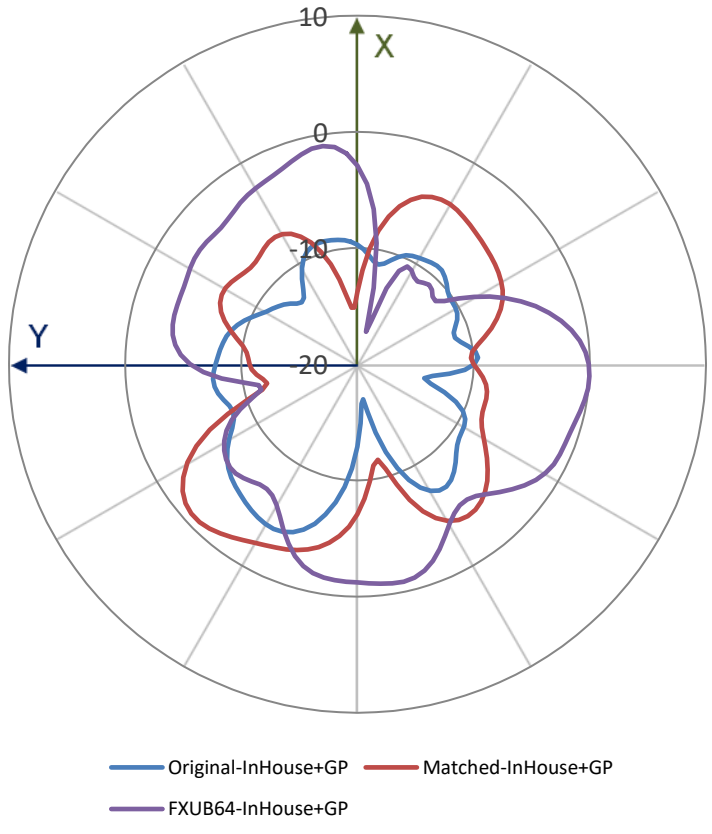
phi = 0



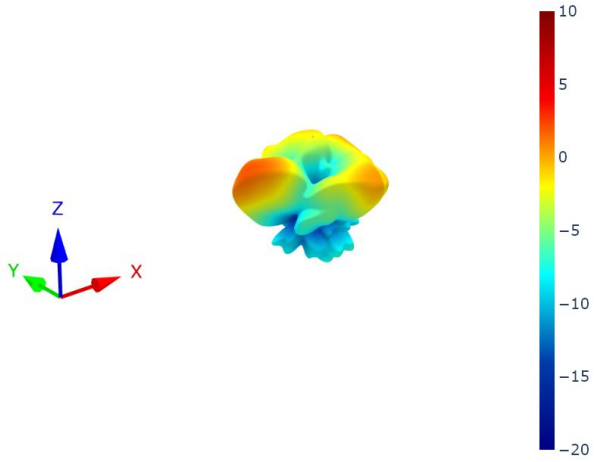
phi = 90



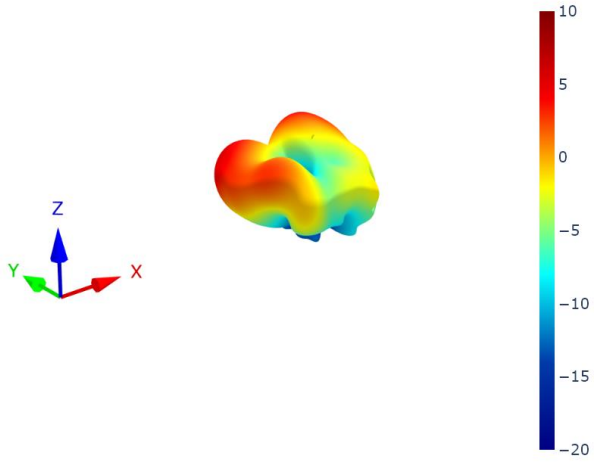
theta = 90



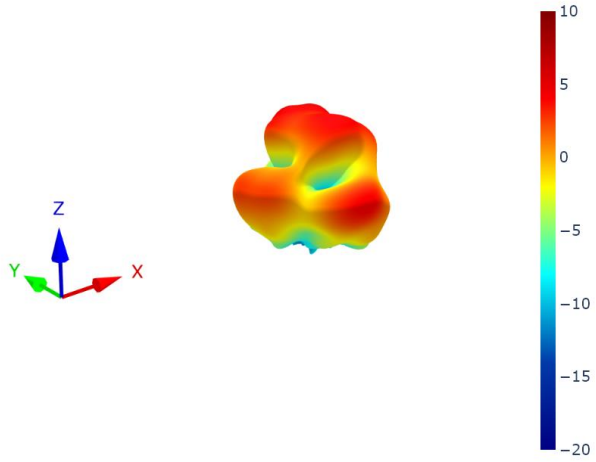
B23 3D Radiation Pattern @2100 MHz [Gtotal]



Original-InHouse+GP



Matched-InHouse+GP



FXUB64-InHouse+GP

Conclusion

- Taoglas has integrated different antenna solutions with the use of PCB based antennas and flexible antennas.

- The PCB based solutions have lower performance due to the current cancelation produced by the metallic ground plane where the device is installed.

- The best performance has been observed with the flexible antennas due to the longer distance to the bottom metallic ground plane. They can be easily installed sticking them on the top shell of the device.

- The FXUB64 antenna presents the best performance obtaining a total efficiency higher than 50% and meeting the requirements. Taoglas recommends the use of this antenna.