



# JUNIPER AP47 ANTENNA REPORT

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Brand: Juniper

Model: AP47



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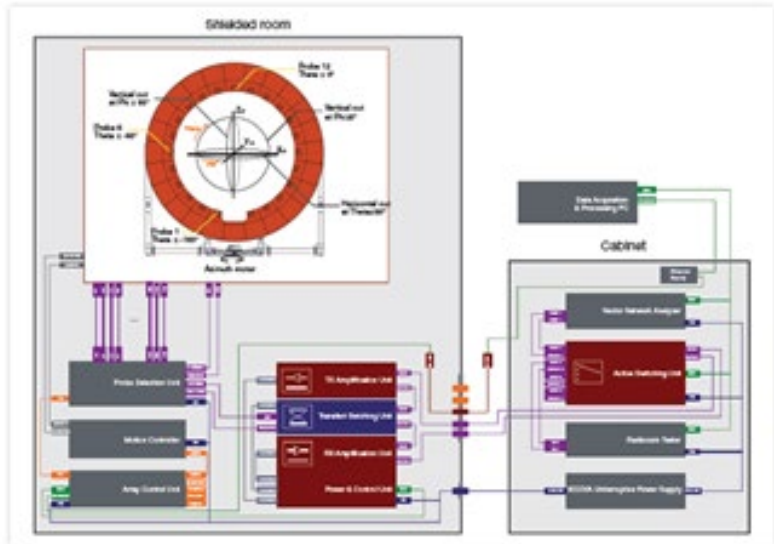
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# Chamber Information

- Test Date : 20241004
- Test Engineer : LiKai Kuo
- Measurement System : SATIMO SG24-L
- Software Name : Wave Studio
- Software Version : 22.5.6



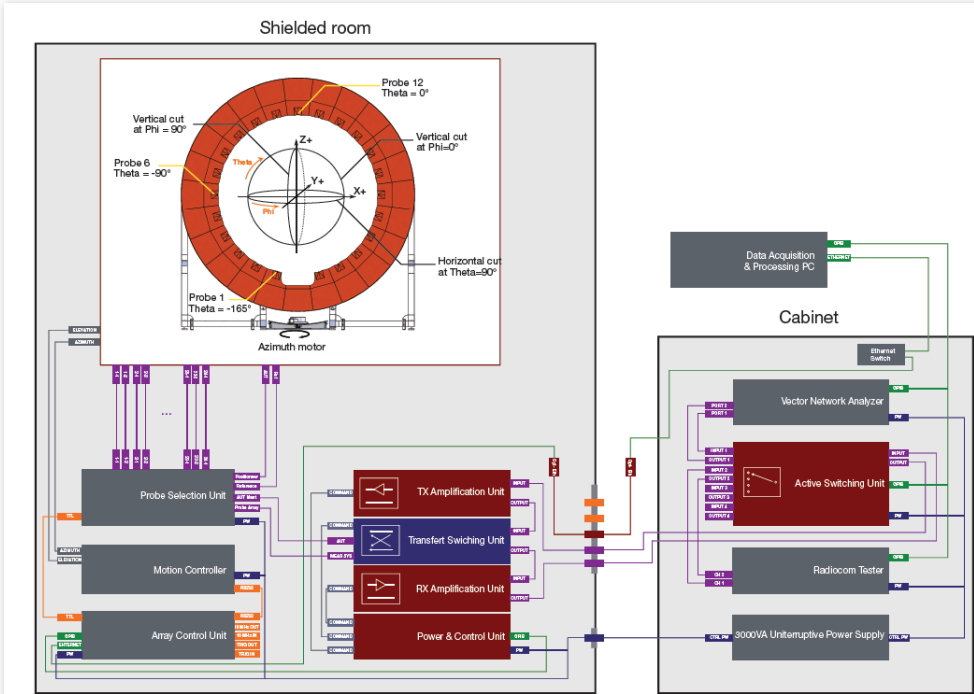
# Test Equipment

## ■ Measurement System : SATIMO SG24-L Chamber

## ■ Measurement Setup

- pattern & gain measurement
  - SATIMO chamber (SG24-L)
  - SATIMO program (wave studio)
  - System overview
- Test item
  - antenna passive test 400MHz~9GHz

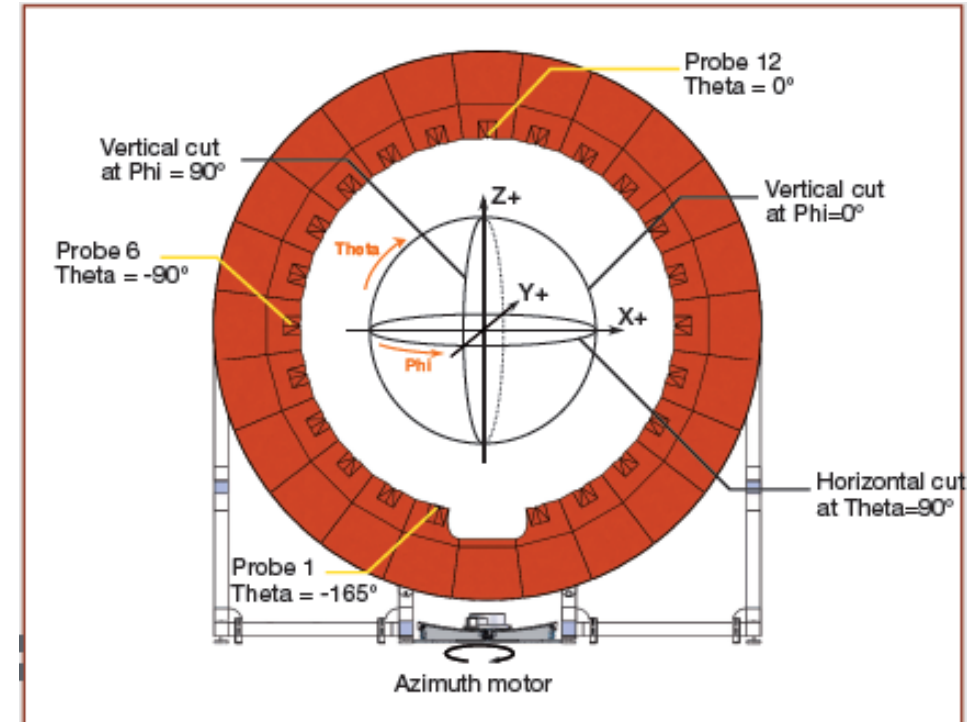
## ■ Calibration Information



| Device                     | Type / Model    | Serial #   | Manufacture | Cal. Date  | Cal. Until |
|----------------------------|-----------------|------------|-------------|------------|------------|
| Antenna Measurement System | SG24-L          | HKG1669S   | MVG-SATIMO  | 2024-06-05 | 2025-06-04 |
| Network Analyzer           | Keysight E5080B | MY59203136 | Keysight    | 2024-06-05 | 2025-06-04 |

# Test Procedure

1. Place the device to be tested on the fixture and align it with the center of the chamber.
2. Connect the antenna cable to the RF connector of the chamber.
3. Use the SW to configure parameters (antenna name, frequency points, measurement angles, antenna dimension), and then run the test SW (wave studio).
4. By phi from  $0^{\circ}$  to  $360^{\circ}$  and theta from  $0^{\circ}$  to  $180^{\circ}$  with a step size of 3 degrees, get the 3D data, including efficiency, peak gain, 2D and 3D radiation patterns.
5. This is far field test for antenna verification.
6. This is passive measurement, which means the device is off and not in any operating mode.



# Summary

The summary of antenna performance are shown in below.

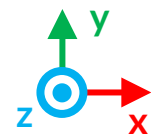
- Radiation efficiency
  - ~56% for 2.4GHz, ~67% for 5GHz, ~63% for 6GHz Wi-Fi Tri-band antennas [TB1, TB2, TB3, TB4]
  - ~59% for 5GHz Wi-Fi 5G antennas [5G1, 5G2, 5G3, 5G4]
  - ~63% for 6GHz Wi-Fi 6G antennas [6G1, 6G2, 6G3, 6G4]
  - ~60% for 2.4GHz ~65% for 5-7GHz Scanning antennas [SC1, SC2]
  - ~68% for 2.4GHz Zigbee(Thread) antenna [Zigbee(Thread)]
  - ~59% for L1, ~61% for L5 GPS antenna [GPS]
  - ~41% for Ch5, ~61% for Ch9 UWB TWR antenna [UWB-TWR] ;
  - ~4% for Ch5, ~19% for Ch9 UWB PDoA antennas [UWB2, UWB3, UWB4]
  - ~16% for 2.4GHz BLE array [Beam1~Beam8]; ~27% for 2.4GHz BLE slot\_directional antenna [Beam9]
  - ~19% for 2.4GHz BLE array [Omni]
- Peak gain
  - 5.0dBi for 2.4GHz, 6.0dBi for 5GHz, 5.9dBi for 6GHz Wi-Fi Tri-band antennas [TB1, TB2, TB3, TB4]
  - 5.2dBi for 5GHz Wi-Fi 5G antennas [5G1, 5G2, 5G3, 5G4]
  - 6.0dBi for 6GHz Wi-Fi 6G antennas [6G1, 6G2, 6G3, 6G4]
  - 3.9dBi for 2.4GHz, 5.9dBi for 5-7GHz Scanning antennas [SC1, SC2]
  - 3.9dBi for 2.4GHz Zigbee(Thread) antenna [Zigbee(Thread)]
  - 2.6dBi for L1, 2.9dBi for L5 GPS antenna [GPS]
  - 4.2dBi for Ch5, 4.7dBi for Ch9 UWB TWR antenna [UWB-TWR] ;
  - -0.7dBi for Ch5, 1.8dBi for Ch9 UWB PDoA antennas [UWB2, UWB3, UWB4]
  - 4.2dBi for 2.4GHz BLE array [Beam1~Beam8]; 3.0dBi for 2.4GHz BLE slot\_directional antenna [Beam9]
  - -0.4dBi for 2.4GHz BLE array [Omni]

# Antenna Placement



Antenna Plate: 246x246mm

| Radio                  | Antenna Type |
|------------------------|--------------|
| TB(1-4)                | PIFA         |
| 5G(1-4)                | Alford Loop  |
| 6G(1-4)                | PIFA         |
| SC(1-2)                | PIFA         |
| GPS                    | PIFA         |
| UWB-TWR                | PIFA         |
| UWB-PDoA               | Patch        |
| Zigbee(Thread)         | PIFA         |
| BLE [Beam1~Beam8/Omni] | PIFA         |
| BLE [Beam9]            | Slot         |



| UWB_TWR | Peak Gain | Position of Peak Gain ( $\theta$ , $\varphi$ ) |
|---------|-----------|------------------------------------------------|
| TWR     | 4.7 dBi   | $\theta = 118^\circ$ , $\varphi = 354^\circ$   |

| Zigbee(Thread) | Peak Gain | Position of Peak Gain ( $\theta$ , $\varphi$ ) |
|----------------|-----------|------------------------------------------------|
| Zigbee(Thread) | 3.9 dBi   | $\theta = 126.5^\circ$ , $\varphi = 90^\circ$  |

| BLE Array            | Peak Gain | Position of Peak Gain ( $\theta$ , $\varphi$ ) |
|----------------------|-----------|------------------------------------------------|
| BLE Array<br>(Beam6) | 4.2 dBi   | $\theta = 53^\circ$ , $\varphi = 222^\circ$    |

# Wi-Fi Tri-Band



## ■ Maximum VSWR

- 2.0:1 on 2.4GHz / 2.0:1 on 5-7GHz

## ■ Minimum Isolation

- 26.2dB on 2.4GHz / 28.8dB on 5GHz /

## ■ Average Efficiency

- ~56% on 2.4GHz / 67% on 5GHz / ~63% on 6GHz

## ■ Peak Gain

- 5.0dBi on 2.4GHz / 6.0dBi on 5GHz / 5.9dBi on 6GHz

## ■ Cable Length

TB1 : 147mm

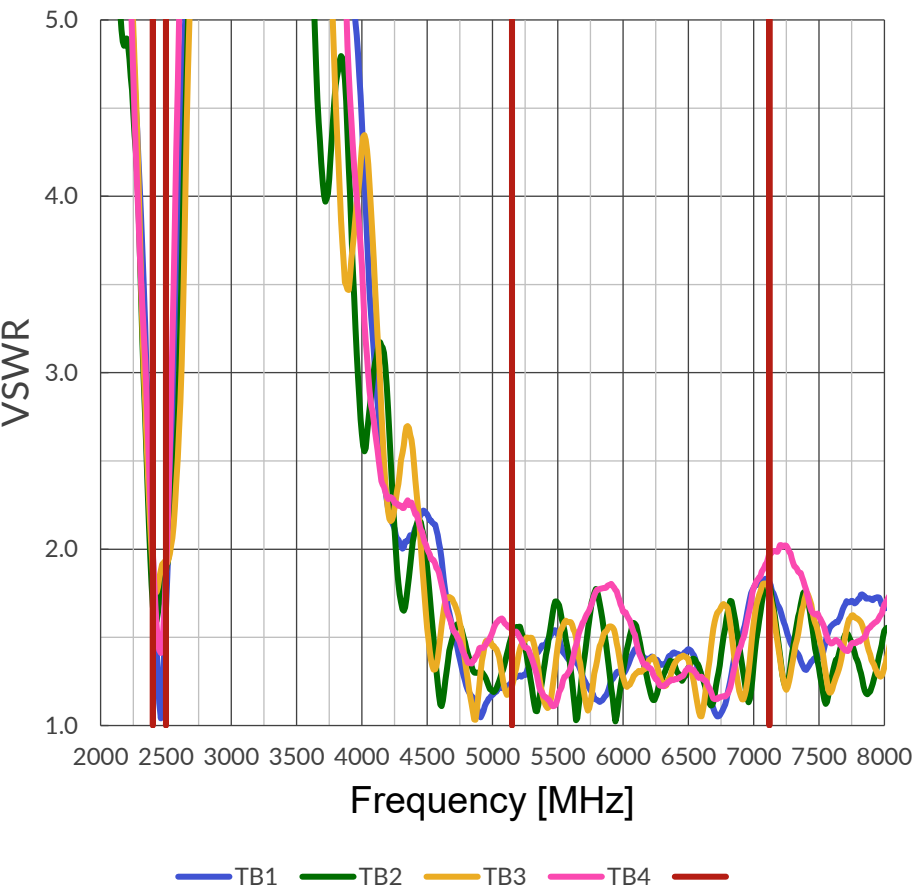
TB2 : 342mm

TB3 : 297mm

TB4 : 97mm

# VSWR

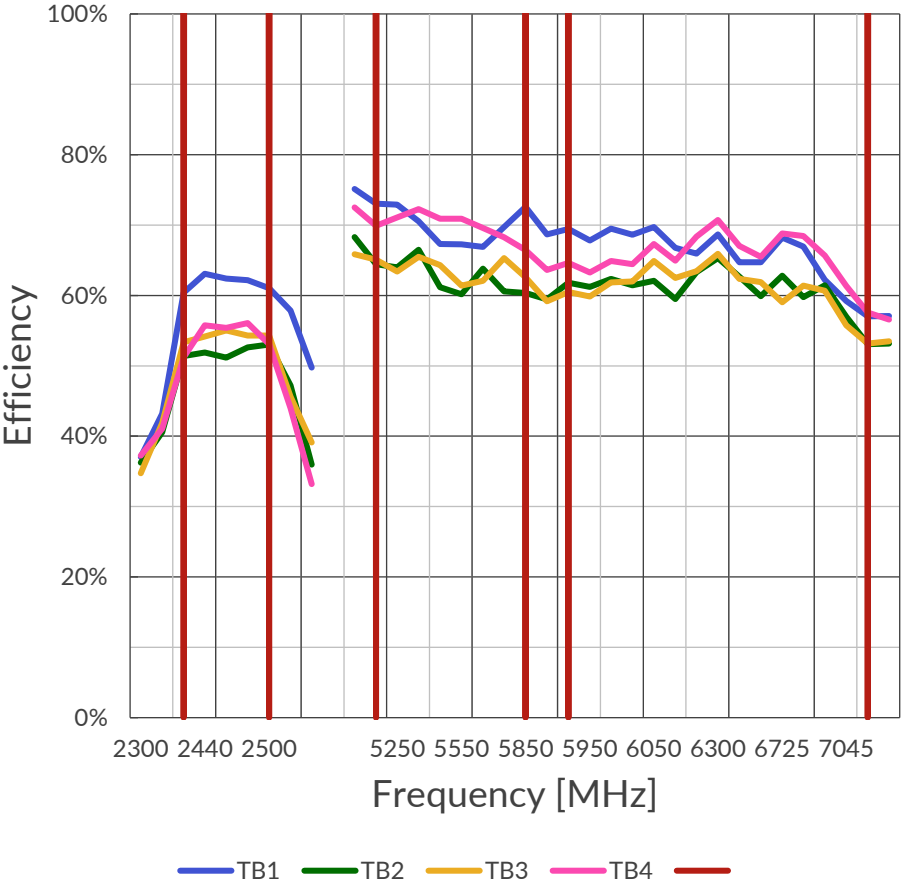
## Wi-Fi Tri-Band



| 2.4GHz  | Max | Mean | Min |
|---------|-----|------|-----|
| TB1     | 2.0 | 1.4  | 1.0 |
| TB2     | 1.9 | 1.7  | 1.6 |
| TB3     | 1.9 | 1.9  | 1.8 |
| TB4     | 2.0 | 1.6  | 1.4 |
| Summary | 2.0 | 1.7  | 1.0 |

| 5GHz    | Max | Mean | Min |
|---------|-----|------|-----|
| TB1     | 1.8 | 1.4  | 1.1 |
| TB2     | 1.8 | 1.4  | 1.0 |
| TB3     | 1.8 | 1.4  | 1.1 |
| TB4     | 2.0 | 1.4  | 1.1 |
| Summary | 2.0 | 1.4  | 1.0 |

# Efficiency Wi-Fi Tri-Band



| 2.4GHz  | Max  | Mean | Min  |
|---------|------|------|------|
| TB1     | 63 % | 62 % | 60 % |
| TB2     | 53 % | 52 % | 51 % |
| TB3     | 55 % | 54 % | 53 % |
| TB4     | 56 % | 54 % | 51 % |
| Summary | 63 % | 56 % | 51 % |

| 5GHz    | Max  | Mean | Min  |
|---------|------|------|------|
| TB1     | 73 % | 70 % | 67 % |
| TB2     | 66 % | 63 % | 60 % |
| TB3     | 65 % | 64 % | 61 % |
| TB4     | 72 % | 70 % | 66 % |
| Summary | 73 % | 67 % | 60 % |

| 6GHz    | Max  | Mean | Min  |
|---------|------|------|------|
| TB1     | 70 % | 66 % | 57 % |
| TB2     | 65 % | 61 % | 53 % |
| TB3     | 66 % | 61 % | 53 % |
| TB4     | 71 % | 66 % | 58 % |
| Summary | 71 % | 63 % | 60 % |

■ Cable Length

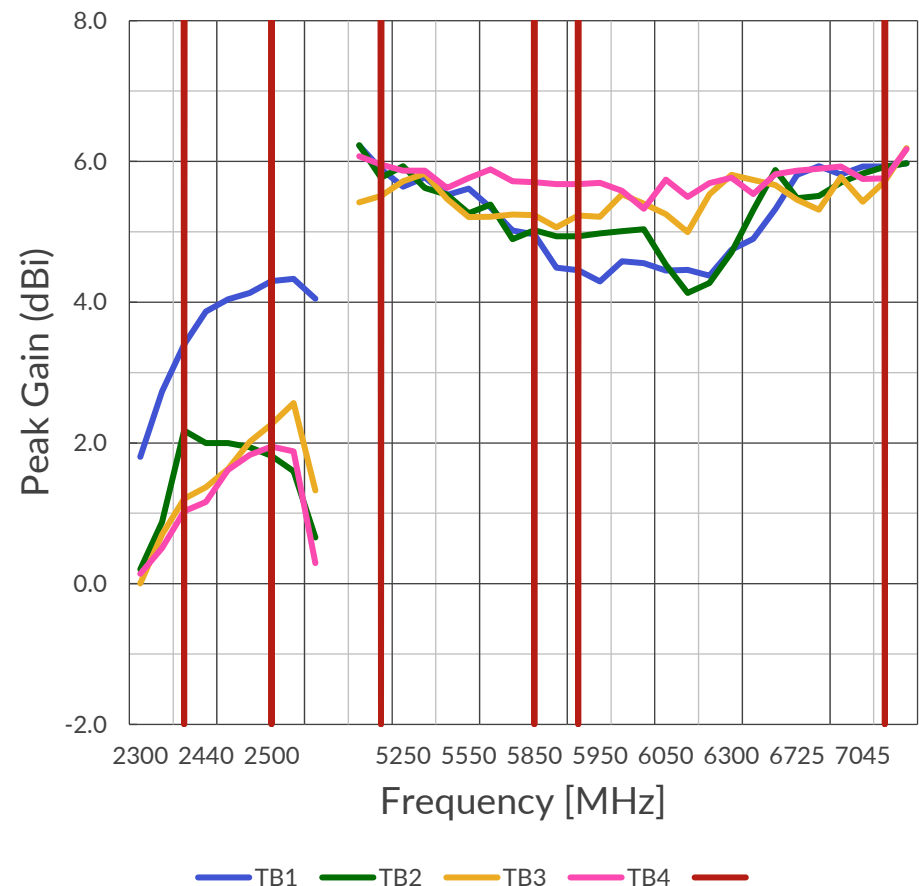
TB1 : 147mm

TB2 : 342mm

TB3 : 297mm

TB4 : 97mm

# Peak Gain Wi-Fi Tri-Band



| 2.4GHz  | Max     | Mean    | Min     |
|---------|---------|---------|---------|
| TB1     | 4.3 dBi | 3.9 dBi | 3.4 dBi |
| TB2     | 2.2 dBi | 2.0 dBi | 1.8 dBi |
| TB3     | 2.3 dBi | 1.7 dBi | 1.2 dBi |
| TB4     | 1.9 dBi | 1.5 dBi | 1.0 dBi |
| Summary | 4.3 dBi | 2.2 dBi | 1.0 dBi |

| 5GHz    | Max     | Mean    | Min     |
|---------|---------|---------|---------|
| TB1     | 5.9 dBi | 5.5 dBi | 5.0 dBi |
| TB2     | 5.9 dBi | 5.4 dBi | 4.9 dBi |
| TB3     | 5.8 dBi | 5.4 dBi | 5.2 dBi |
| TB4     | 6.0 dBi | 5.8 dBi | 5.6 dBi |
| Summary | 6.0 dBi | 5.5 dBi | 4.9 dBi |

| 6GHz    | Max     | Mean    | Min     |
|---------|---------|---------|---------|
| TB1     | 5.9 dBi | 5.0 dBi | 4.3 dBi |
| TB2     | 5.9 dBi | 5.1 dBi | 4.1 dBi |
| TB3     | 5.8 dBi | 5.5 dBi | 5.0 dBi |
| TB4     | 5.9 dBi | 5.7 dBi | 5.3 dBi |
| Summary | 5.9 dBi | 5.3 dBi | 4.1 dBi |

■ Cable Length

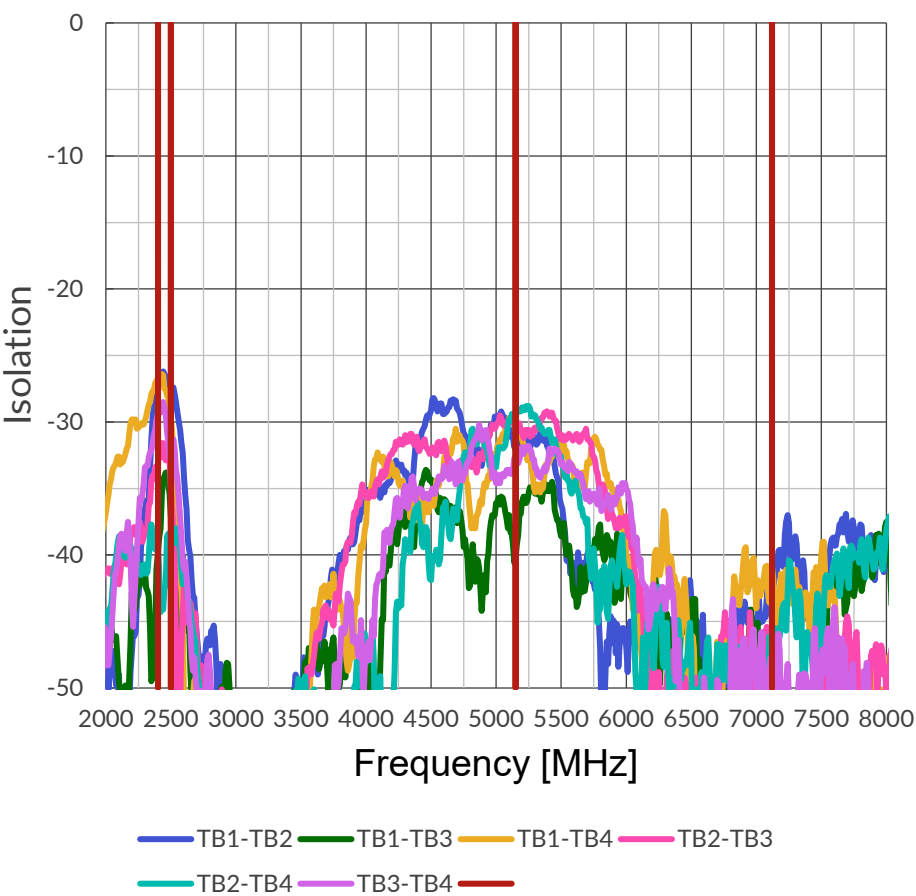
TB1 : 147mm

TB2 : 342mm

TB3 : 297mm

TB4 : 97mm

# Isolation Wi-Fi Tri-Band

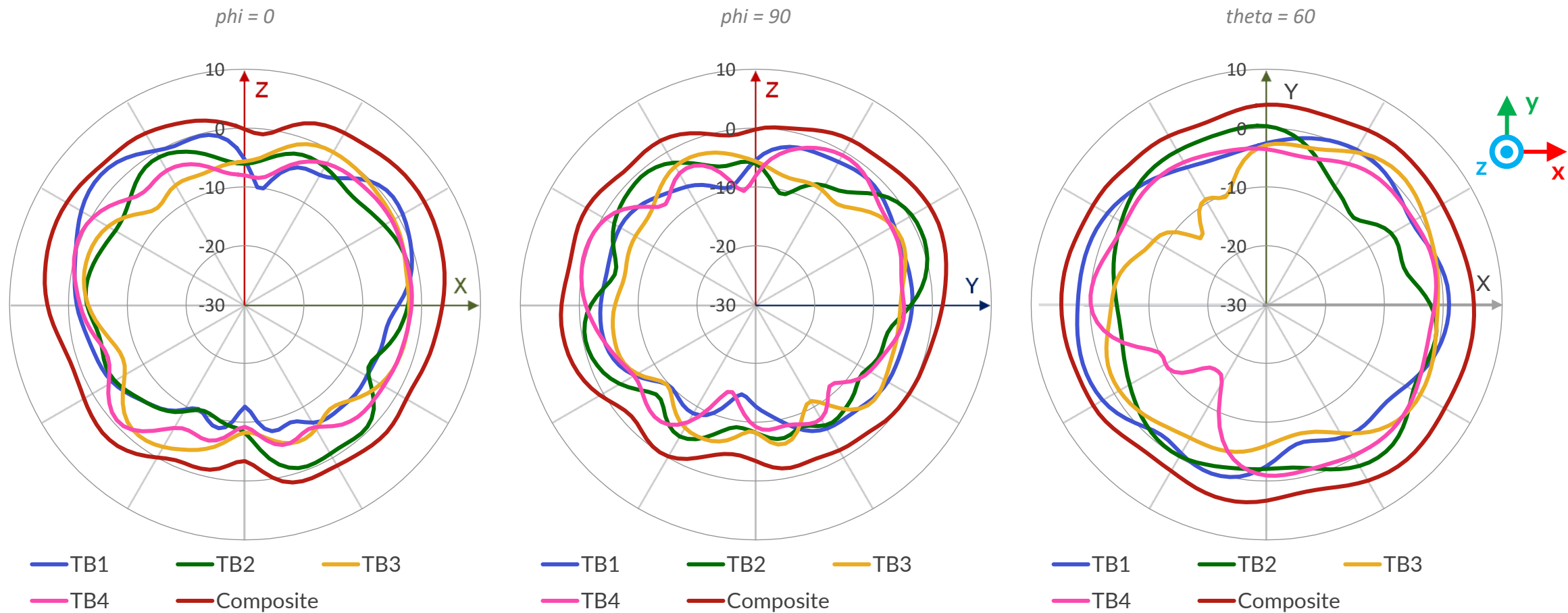


| 2.4GHz  | Max   | Mean  | Min   |
|---------|-------|-------|-------|
| TB1-TB2 | -26.2 | -26.9 | -27.5 |
| TB1-TB3 | -33.8 | -35.9 | -39.7 |
| TB1-TB4 | -26.4 | -27.6 | -29.7 |
| TB2-TB3 | -31.6 | -32.6 | -35.1 |
| TB2-TB4 | -38.4 | -41.2 | -44.3 |
| TB3-TB4 | -28.5 | -30.0 | -32.7 |
| Summary | -26.2 | -32.4 | -44.3 |

| 5GHz    | Max   | Mean  | Min   |
|---------|-------|-------|-------|
| TB1-TB2 | -30.6 | -43.3 | -63.7 |
| TB1-TB3 | -34.5 | -44.0 | -65.4 |
| TB1-TB4 | -30.1 | -40.3 | -61.5 |
| TB2-TB3 | -29.2 | -41.8 | -70.8 |
| TB2-TB4 | -28.8 | -43.4 | -69.3 |
| TB3-TB4 | -31.8 | -42.4 | -65.0 |
| Summary | -28.8 | -42.5 | -70.8 |

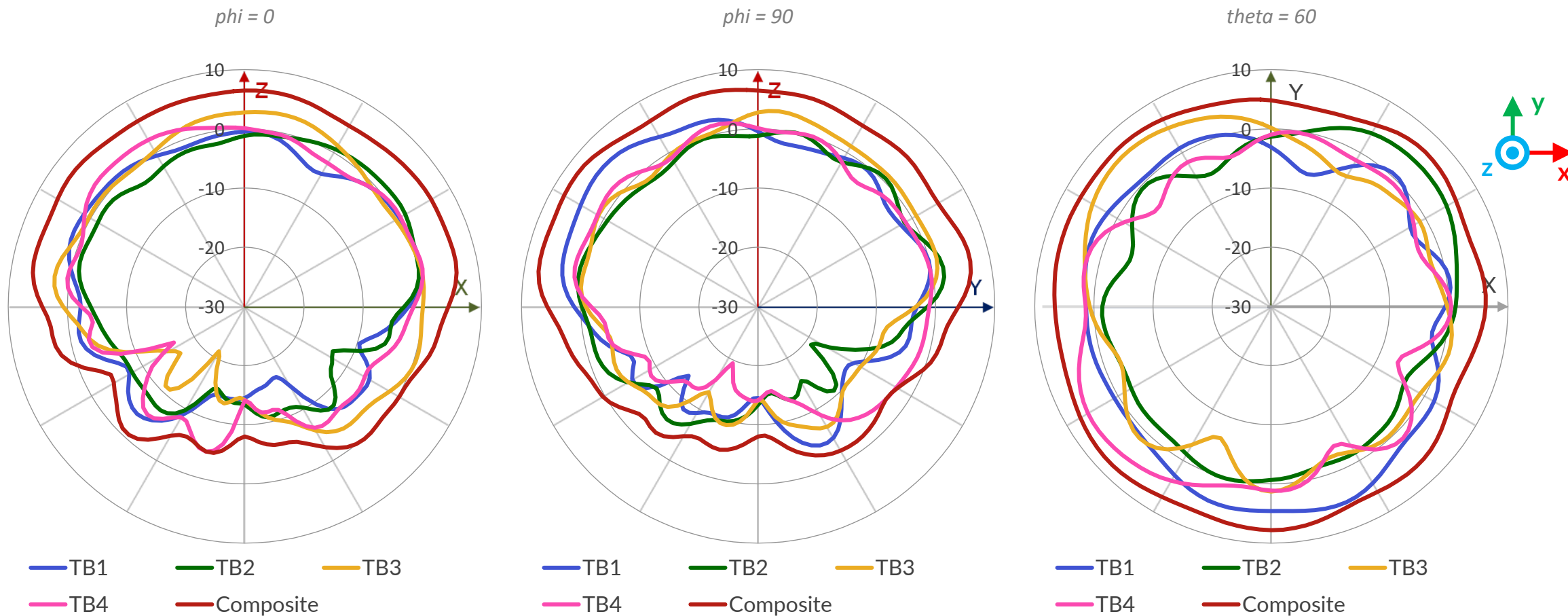
# Realized Gain Pattern

## Wi-Fi Tri-Band @2450MHz for Gtotal

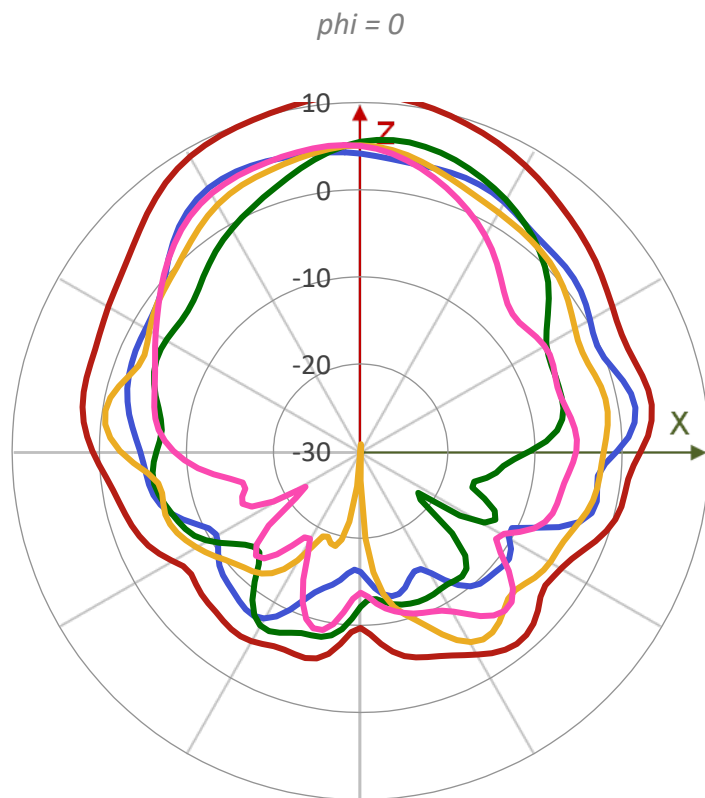


# Realized Gain Pattern

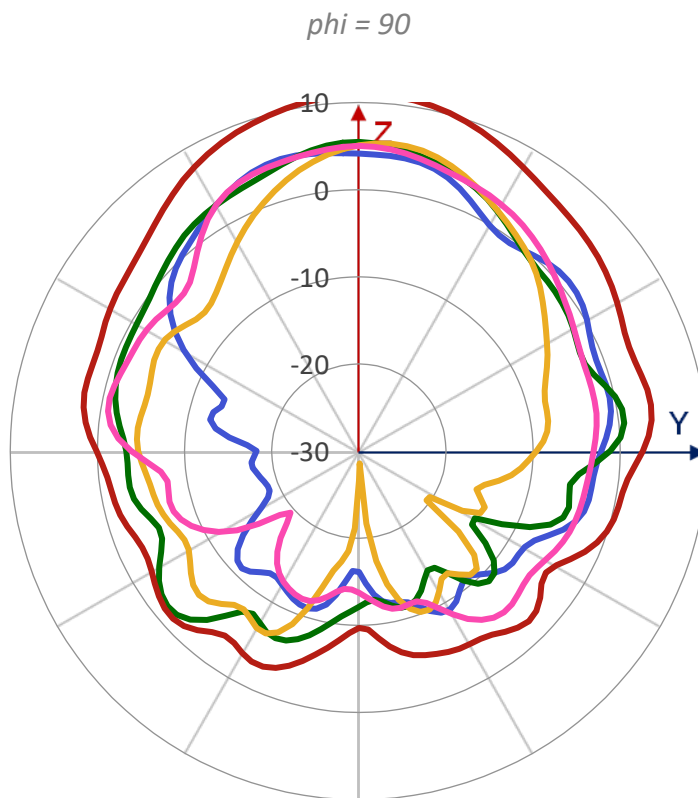
## Wi-Fi Tri-Band @5250MHz for Gtotal



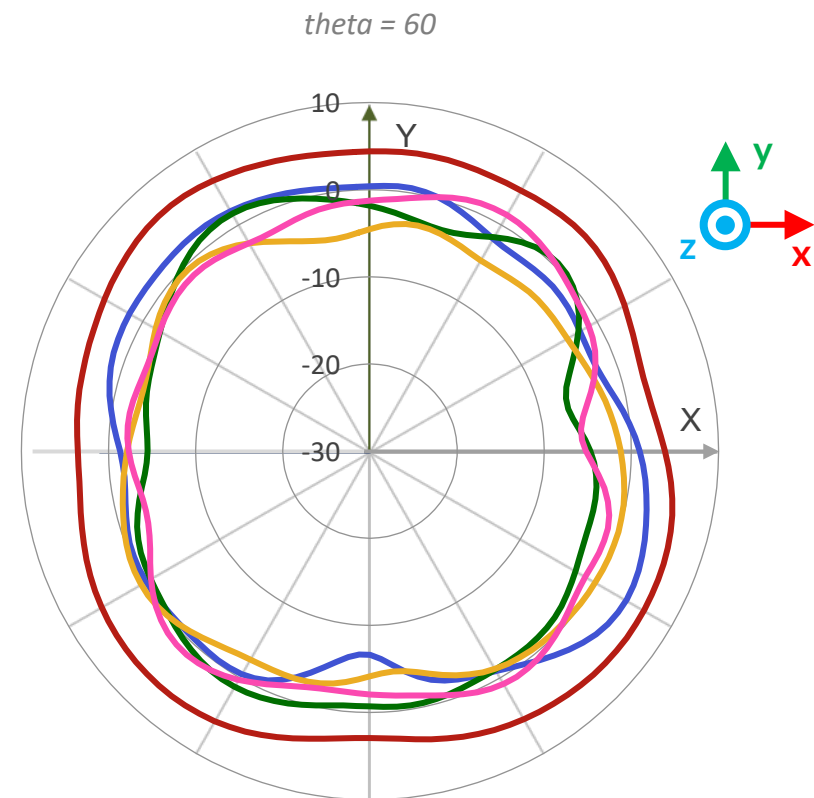
# Realized Gain Pattern Wi-Fi Tri-Band @6885MHz for Gtotal



— TB1 — TB2 — TB3  
— TB4 — Composite



— TB1 — TB2 — TB3  
— TB4 — Composite



— TB1 — TB2 — TB3  
— TB4 — Composite

# Wi-Fi 5G



- **Maximum VSWR**

- 2.0:1 on 5GHz

- **Minimum Isolation**

- 31.4dB on 5GHz

- **Average Efficiency**

- ~59% on 5GHz

- **Peak Gain**

- 5.2dBi on 5GHz

- **Cable Length**

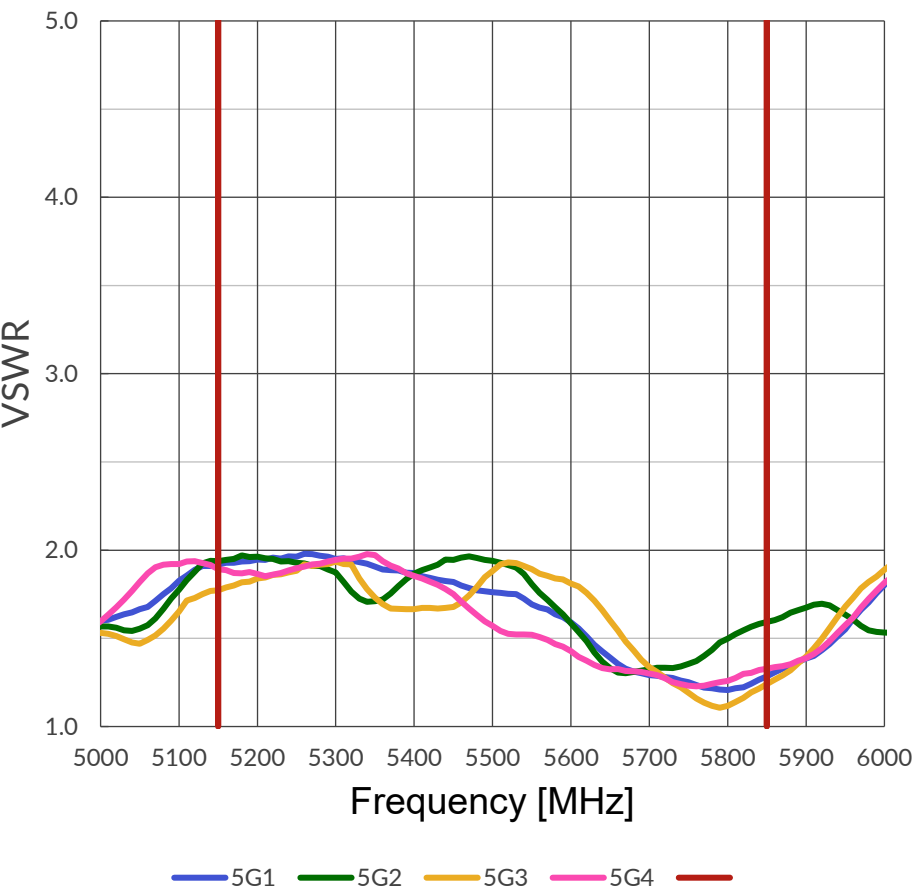
5G1 : 134mm

5G2 : 325mm

5G3 : 282mm

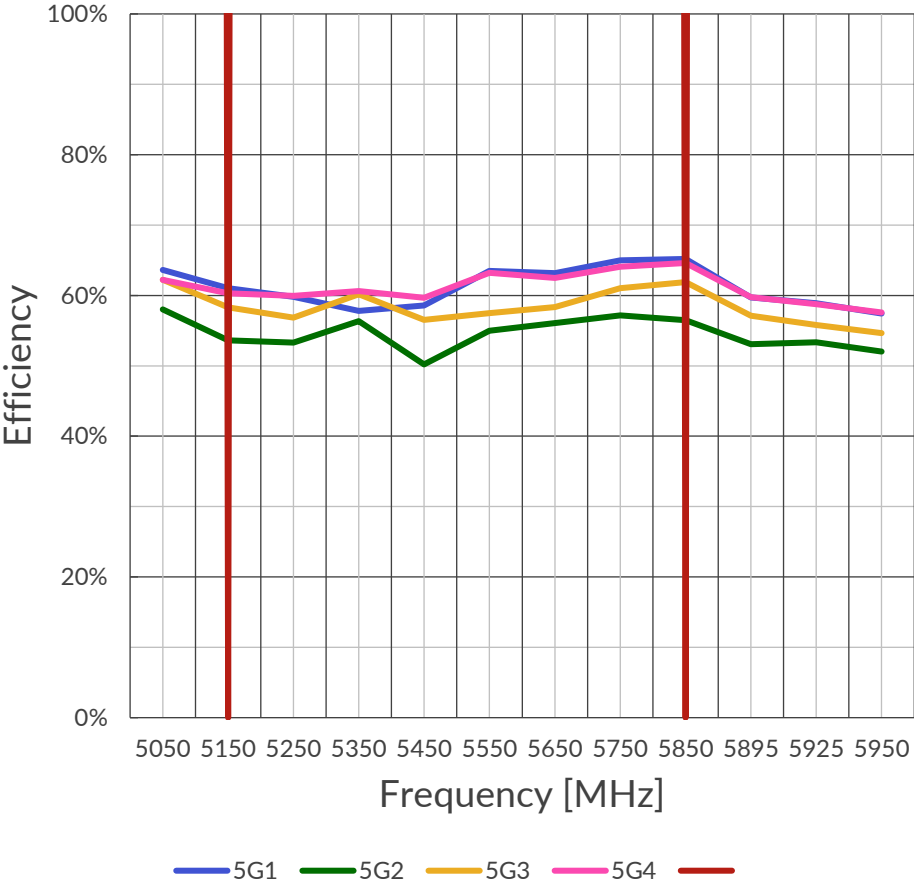
5G4 : 99mm

# VSWR Wi-Fi 5G



| 5GHz    | Max | Mean | Min |
|---------|-----|------|-----|
| 5G1     | 2.0 | 1.7  | 1.2 |
| 5G2     | 2.0 | 1.7  | 1.3 |
| 5G3     | 1.9 | 1.6  | 1.1 |
| 5G4     | 2.0 | 1.6  | 1.2 |
| Summary | 2.0 | 1.7  | 1.1 |

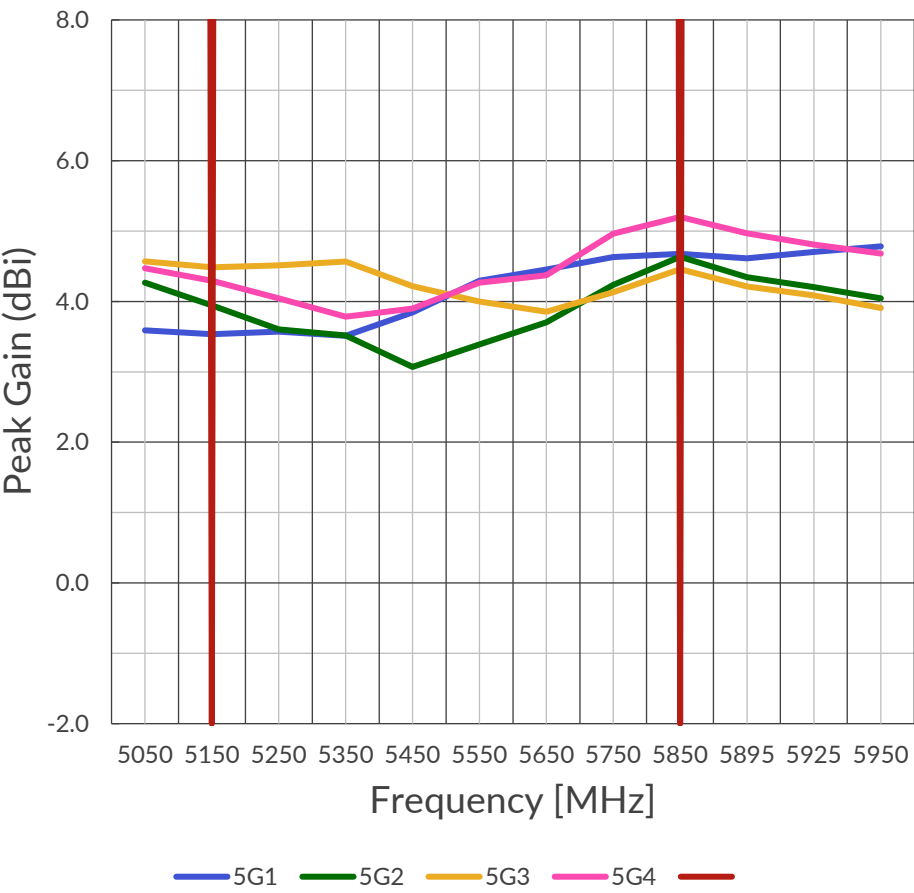
# Efficiency Wi-Fi 5G



| 5GHz    | Max  | Mean | Min  |
|---------|------|------|------|
| 5G1     | 65 % | 62 % | 58 % |
| 5G2     | 57 % | 55 % | 50 % |
| 5G3     | 62 % | 59 % | 57 % |
| 5G4     | 65 % | 62 % | 60 % |
| Summary | 65 % | 59 % | 50 % |

- Cable Length
- 5G1 : 134mm
  - 5G2 : 325mm
  - 5G3 : 282mm
  - 5G4 : 99mm

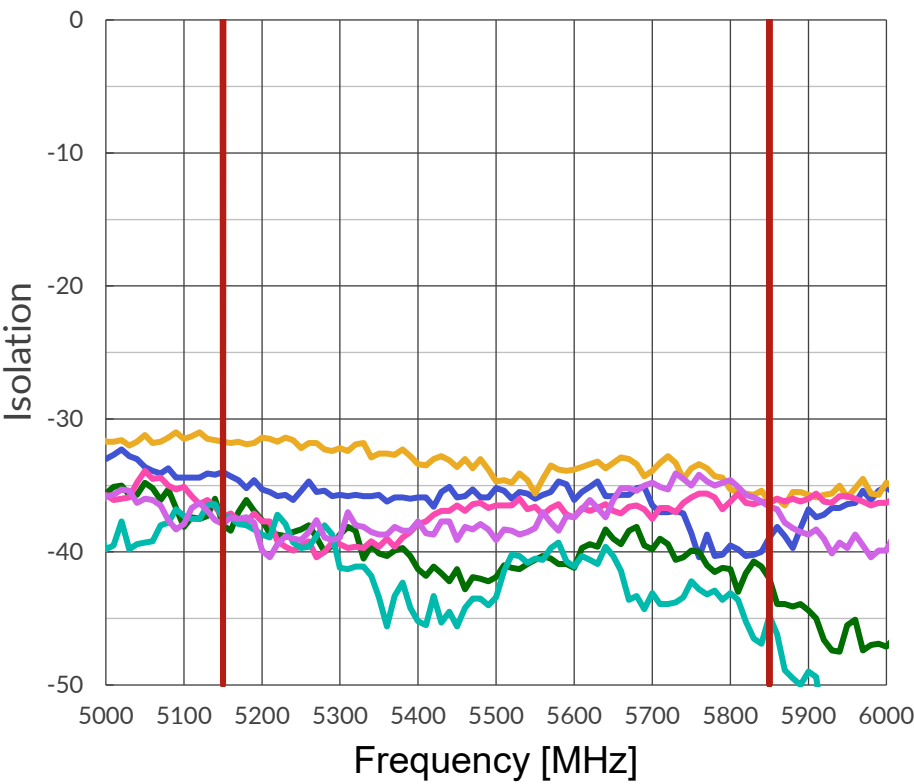
# Peak Gain Wi-Fi 5G



| 5GHz    | Max     | Mean    | Min     |
|---------|---------|---------|---------|
| 5G1     | 4.7 dBi | 4.1 dBi | 3.5 dBi |
| 5G2     | 4.6 dBi | 3.8 dBi | 3.1 dBi |
| 5G3     | 4.6 dBi | 4.3 dBi | 3.9 dBi |
| 5G4     | 5.2 dBi | 4.4 dBi | 3.8 dBi |
| Summary | 5.2 dBi | 4.1 dBi | 3.1 dBi |

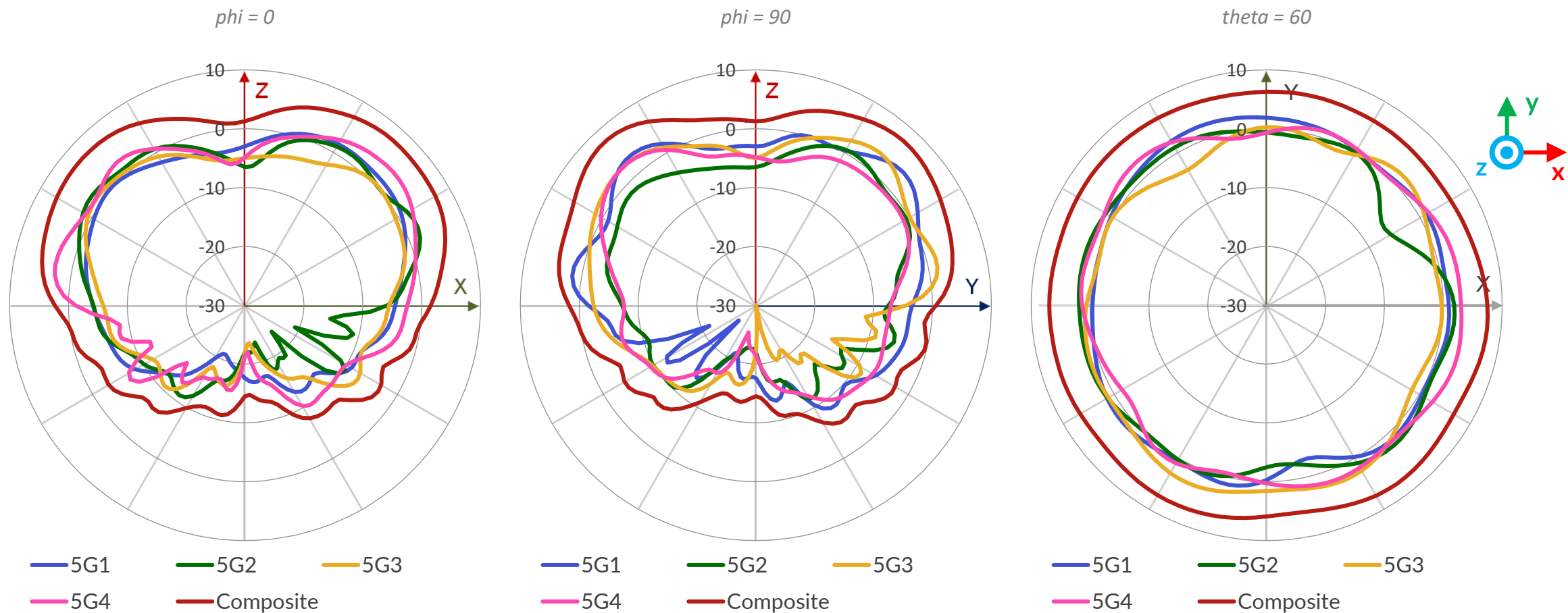
- Cable Length
- 5G1 : 134mm
  - 5G2 : 325mm
  - 5G3 : 282mm
  - 5G4 : 99mm

# Isolation Wi-Fi 5G



| 5GHz    | Max   | Mean  | Min   |
|---------|-------|-------|-------|
| 5G1-5G2 | -34.0 | -36.3 | -40.4 |
| 5G1-5G3 | -36.1 | -40.0 | -43.0 |
| 5G1-5G4 | -31.4 | -33.3 | -36.2 |
| 5G2-5G3 | -35.6 | -37.4 | -40.4 |
| 5G2-5G4 | -37.2 | -41.8 | -46.9 |
| 5G3-5G4 | -34.1 | -37.3 | -40.4 |
| Summary | -31.4 | -37.7 | -46.9 |

# Realized Gain Pattern Wi-Fi 5G @5450MHz for Gtotal



# Wi-Fi 6G



- **Maximum VSWR**

- 2.0:1 on 6GHz

- **Minimum Isolation**

- 28.8dB on 6GHz

- **Average Efficiency**

- ~63% on 6GHz

- **Peak Gain**

- 6.0dBi on 6GHz

- **Cable Length**

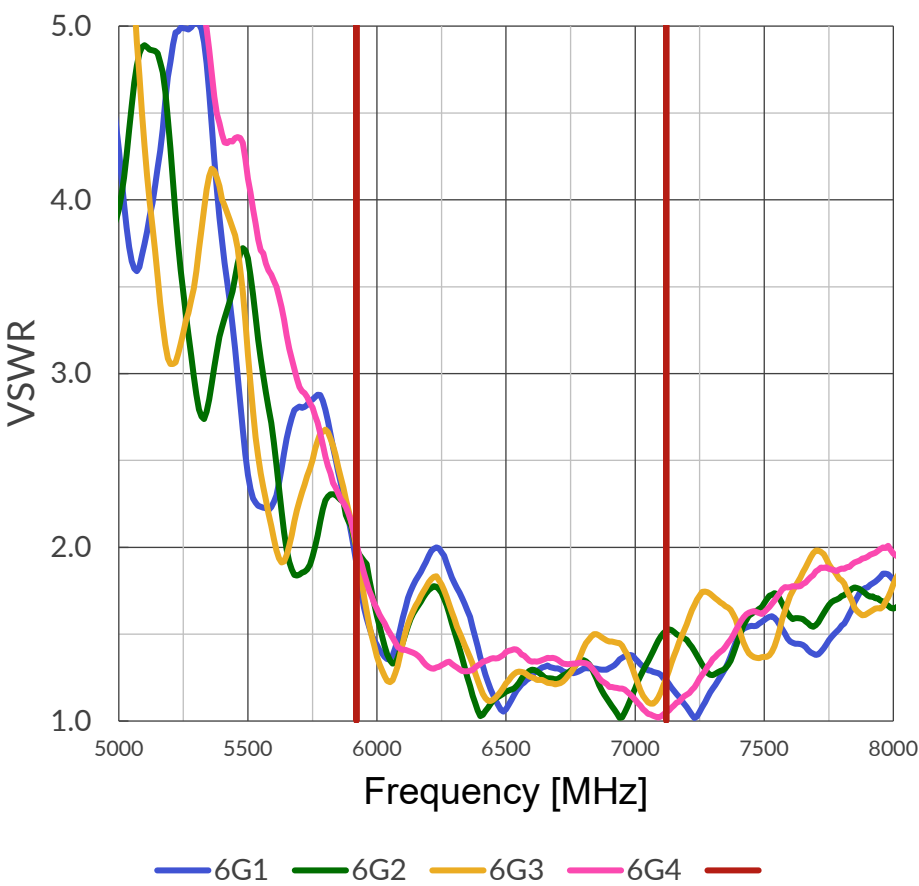
6G1 : 209mm

6G2 : 277mm

6G3 : 244mm

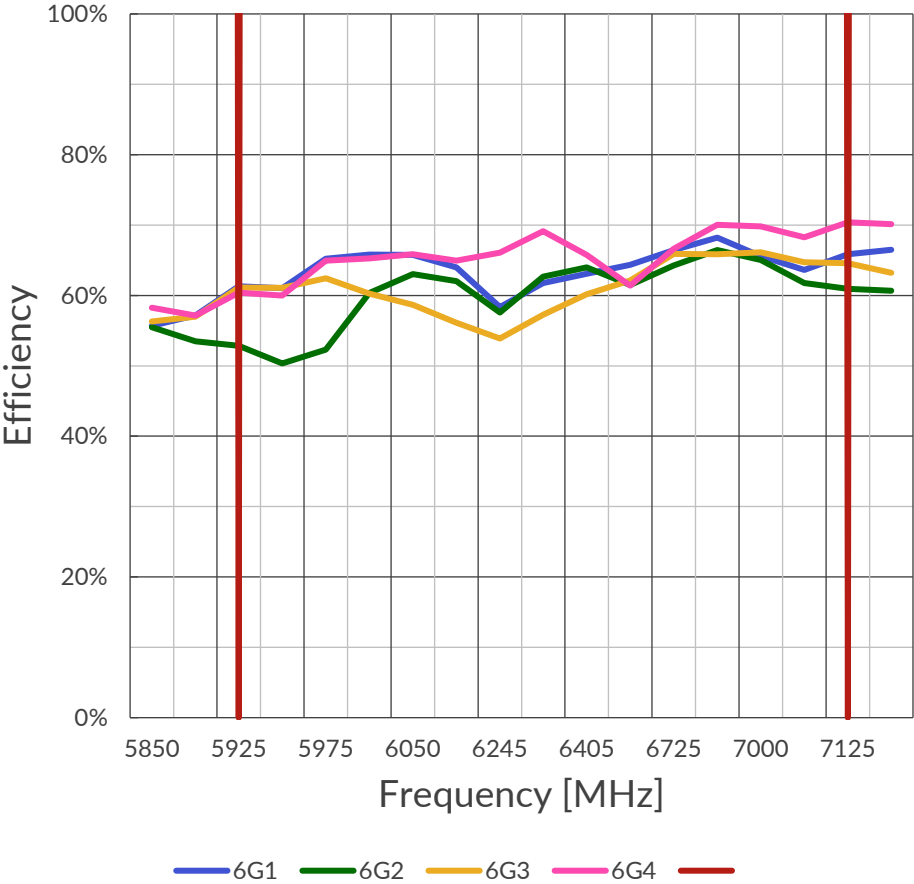
6G4 : 47mm

# VSWR Wi-Fi 6G



| 6GHz    | Max | Mean | Min |
|---------|-----|------|-----|
| 6G1     | 2.0 | 1.4  | 1.1 |
| 6G2     | 2.0 | 1.4  | 1.0 |
| 6G3     | 2.0 | 1.4  | 1.1 |
| 6G4     | 2.0 | 1.3  | 1.0 |
| Summary | 2.0 | 1.4  | 1.0 |

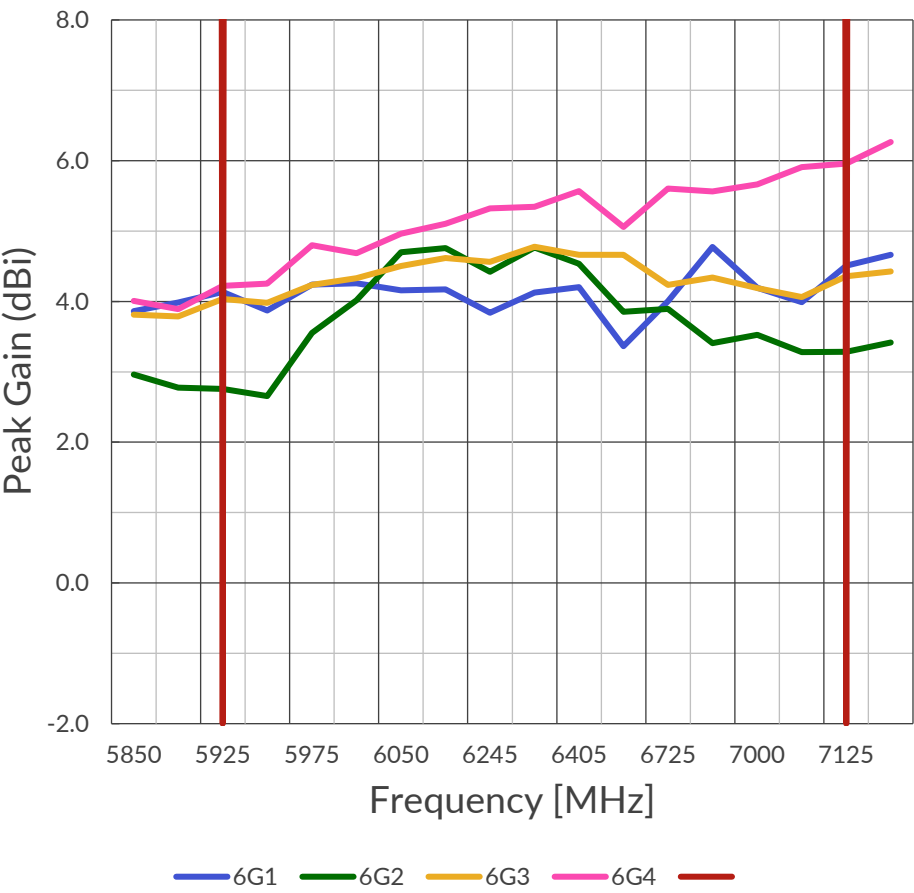
# Efficiency Wi-Fi 6G



| 5GHz    | Max  | Mean | Min  |
|---------|------|------|------|
| 6G1     | 68 % | 64 % | 58 % |
| 6G2     | 66 % | 60 % | 50 % |
| 6G3     | 66 % | 61 % | 54 % |
| 6G4     | 70 % | 66 % | 60 % |
| Summary | 70 % | 63 % | 50 % |

- Cable Length
- 6G1 : 209mm
  - 6G2 : 277mm
  - 6G3 : 244mm
  - 6G4 : 47mm

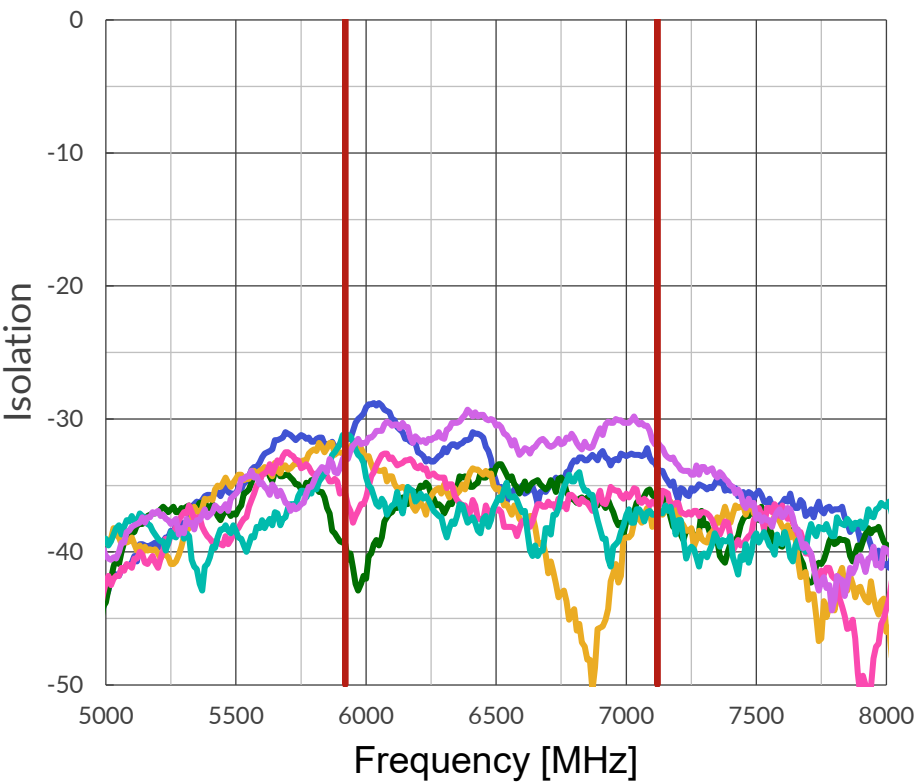
# Peak Gain Wi-Fi 6G



| 5GHz    | Max     | Mean    | Min     |
|---------|---------|---------|---------|
| 6G1     | 4.8 dBi | 4.1 dBi | 3.4 dBi |
| 6G2     | 4.8 dBi | 3.8 dBi | 2.7 dBi |
| 6G3     | 4.8 dBi | 4.4 dBi | 4.0 dBi |
| 6G4     | 6.0 dBi | 5.2 dBi | 4.2 dBi |
| Summary | 6.0 dBi | 4.4 dBi | 2.7 dBi |

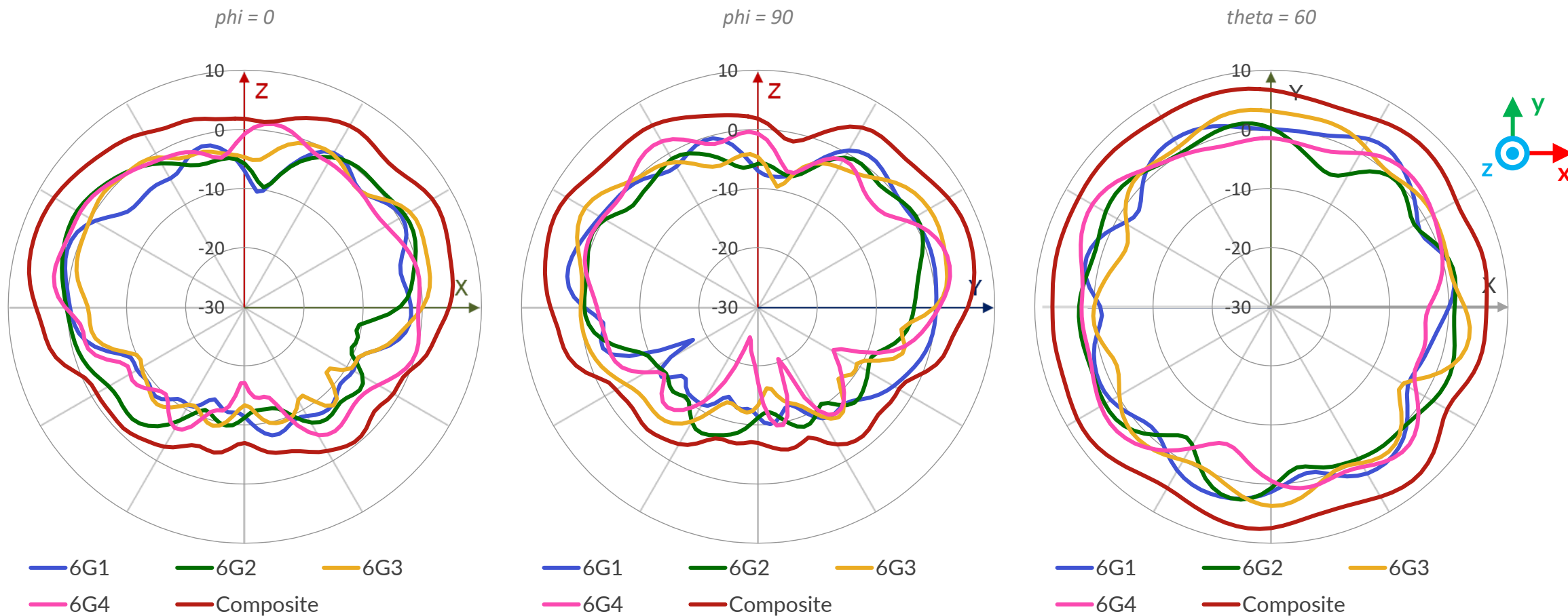
- Cable Length
- 6G1 : 209mm
  - 6G2 : 277mm
  - 6G3 : 244mm
  - 6G4 : 47mm

# Isolation Wi-Fi 6G



| 6GHz    | Max   | Mean  | Min   |
|---------|-------|-------|-------|
| 6G1-6G2 | -28.8 | -32.7 | -36.4 |
| 6G1-6G3 | -33.4 | -36.3 | -42.9 |
| 6G1-6G4 | -31.8 | -37.8 | -50.4 |
| 6G2-6G3 | -32.6 | -35.8 | -38.8 |
| 6G2-6G4 | -31.2 | -36.7 | -41.1 |
| 6G3-6G4 | -29.3 | -31.1 | -33.0 |
| Summary | -28.8 | -35.0 | -50.4 |

# Realized Gain Pattern Wi-Fi 6G @6565MHz for Gtotal



# Scanning



## ■ Maximum VSWR

- 2.0:1 on 2.4GHz / 2.0:1 on 5-7GHz

## ■ Minimum Isolation

- 30.5dB on 2.4GHz / 35.0dB on 5-7GHz

## ■ Average Efficiency

- ~60% on 2.4GHz / ~65% on 5-7GHz

## ■ Peak Gain

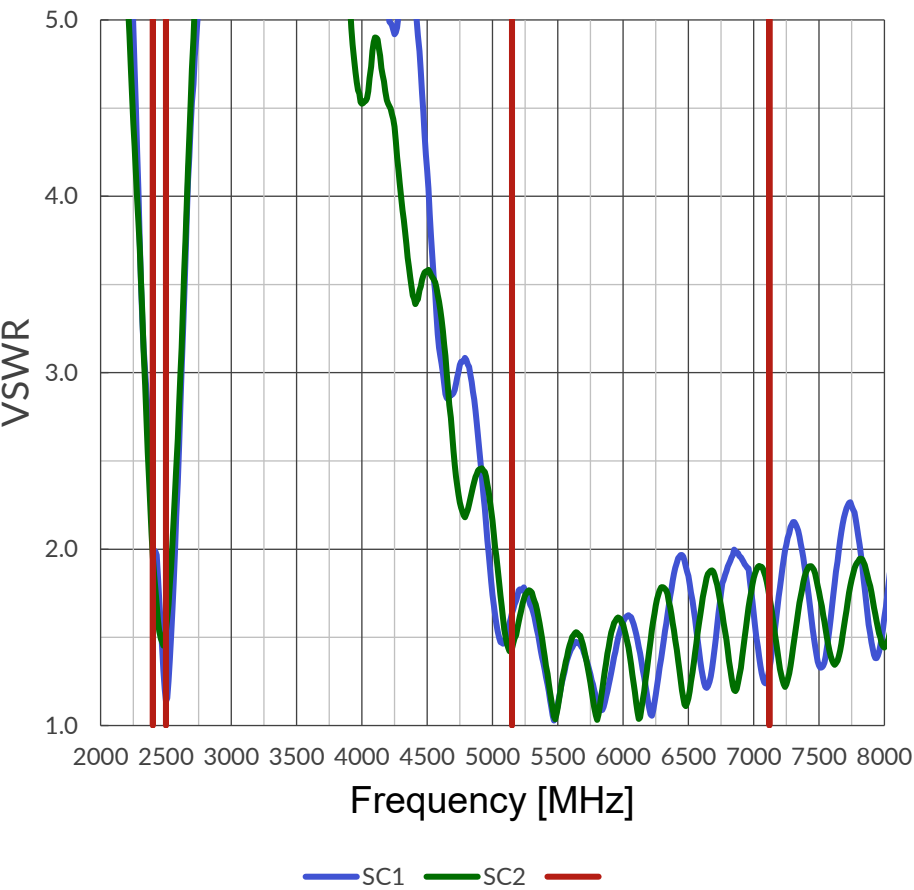
- 3.9dBi on 4.0GHz / 5.9dBi on 5-7GHz

## ■ Cable Length

SC1 : 226mm

SC2 : 268mm

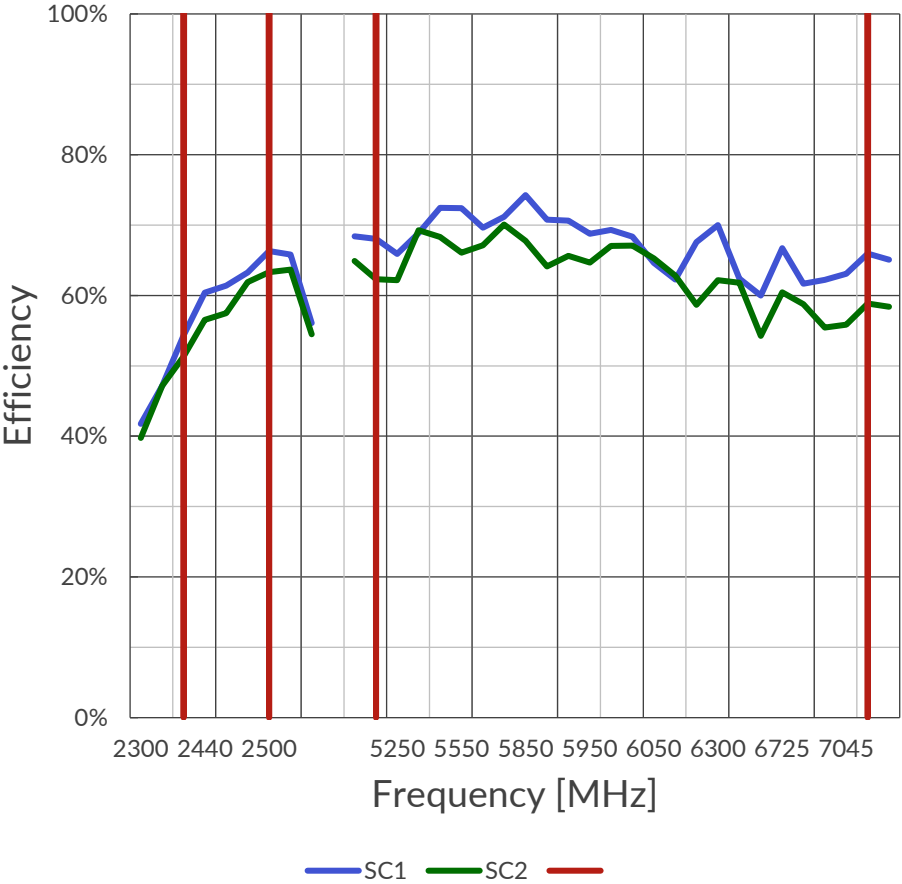
# VSWR Scanning



| 2.4GHz  | Max | Mean | Min |
|---------|-----|------|-----|
| SC1     | 2.0 | 1.5  | 1.1 |
| SC2     | 2.0 | 1.6  | 1.2 |
| Summary | 2.0 | 1.5  | 1.1 |

| 5GHz    | Max | Mean | Min |
|---------|-----|------|-----|
| SC1     | 2.0 | 1.5  | 1.0 |
| SC2     | 2.0 | 1.5  | 1.1 |
| Summary | 2.0 | 1.5  | 1.0 |

# Efficiency Scanning



| 2.4GHz  | Max  | Mean | Min  |
|---------|------|------|------|
| SC1     | 66 % | 61 % | 54 % |
| SC2     | 63 % | 58 % | 51 % |
| Summary | 66 % | 60 % | 51 % |

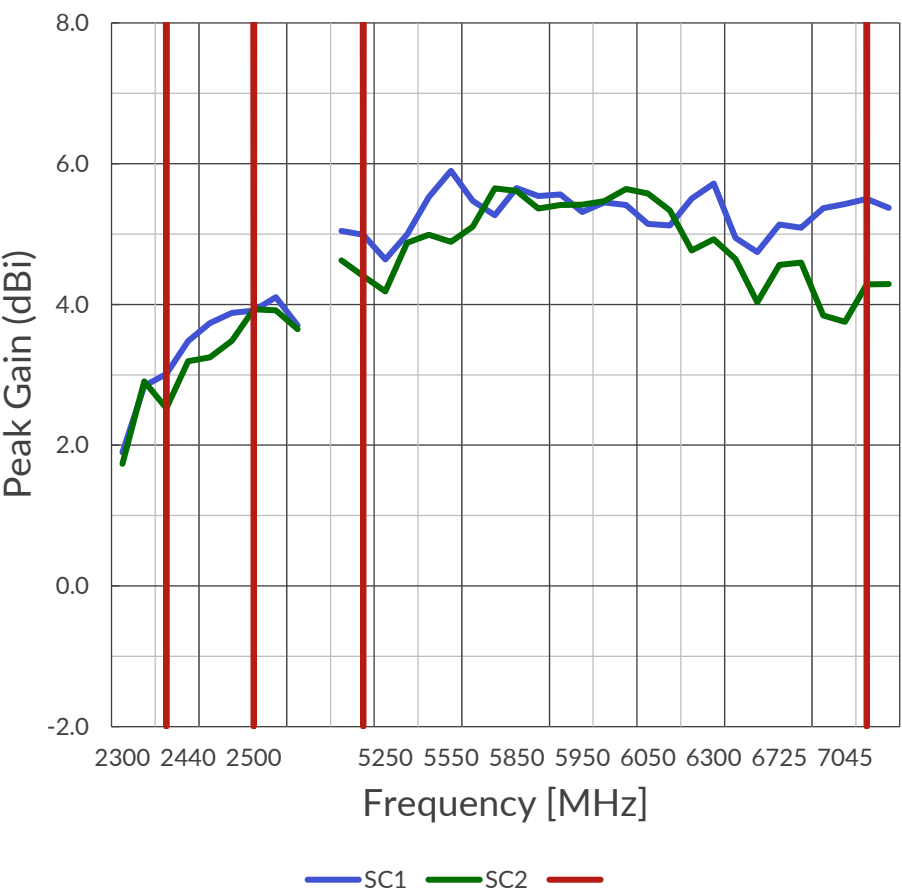
| 5GHz    | Max  | Mean | Min  |
|---------|------|------|------|
| SC1     | 74 % | 67 % | 60 % |
| SC2     | 70 % | 63 % | 54 % |
| Summary | 74 % | 65 % | 54 % |

■ Cable Length

SC1 : 226mm

SC2 : 268mm

# Peak Gain Scanning



| 2.4GHz  | Max     | Mean    | Min     |
|---------|---------|---------|---------|
| SC1     | 3.9 dBi | 3.6 dBi | 3.0 dBi |
| SC2     | 3.9 dBi | 3.3 dBi | 2.5 dBi |
| Summary | 3.9 dBi | 3.4 dBi | 2.5 dBi |

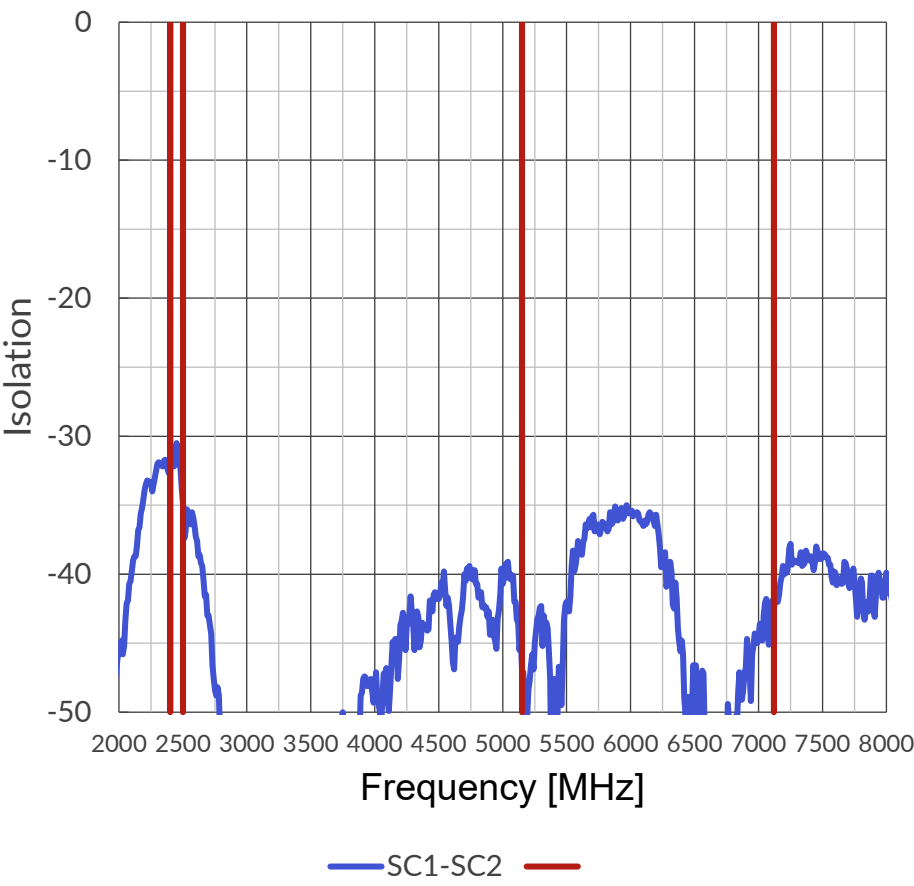
| 5GHz    | Max     | Mean    | Min     |
|---------|---------|---------|---------|
| SC1     | 5.9 dBi | 5.3 dBi | 4.6 dBi |
| SC2     | 5.6 dBi | 4.9 dBi | 3.8 dBi |
| Summary | 5.9 dBi | 5.1 dBi | 3.8 dBi |

■ Cable Length

SC1 : 226mm

SC2 : 268mm

# Isolation Scanning

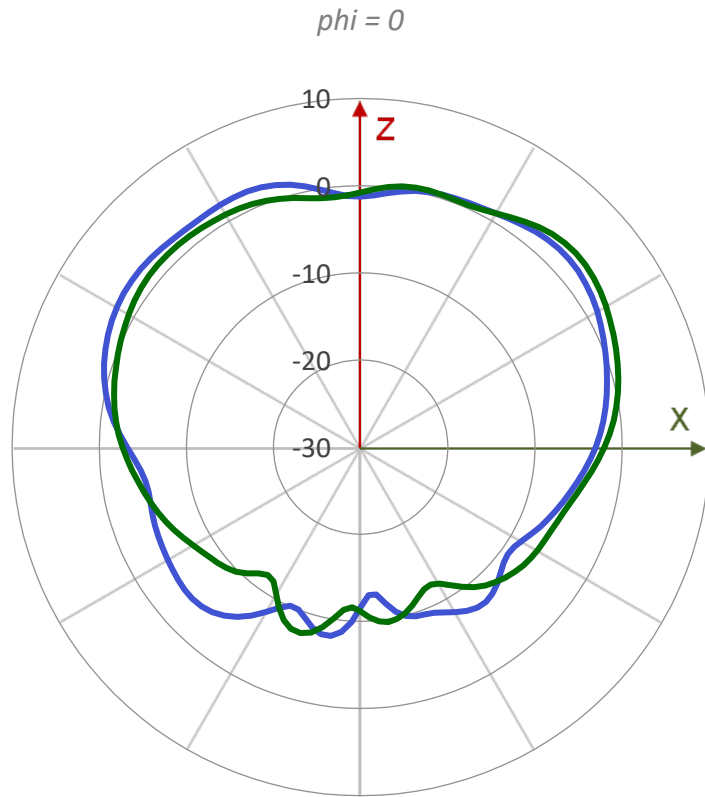


| 2.4GHz  | Max   | Mean  | Min   |
|---------|-------|-------|-------|
| SC1-SC2 | -30.5 | -32.1 | -34.9 |

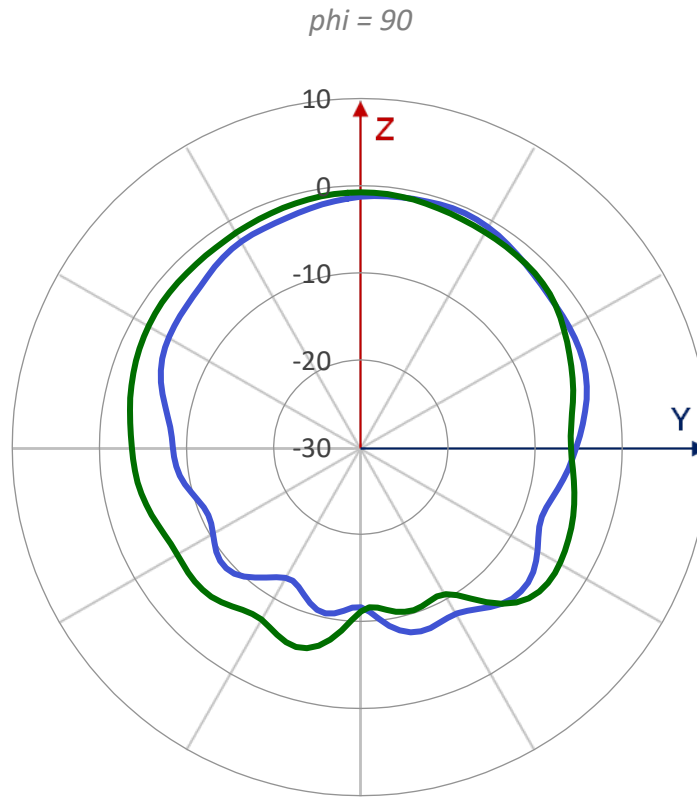
| 5GHz    | Max   | Mean  | Min   |
|---------|-------|-------|-------|
| SC1-SC2 | -35.0 | -43.3 | -57.5 |

# Realized Gain Pattern

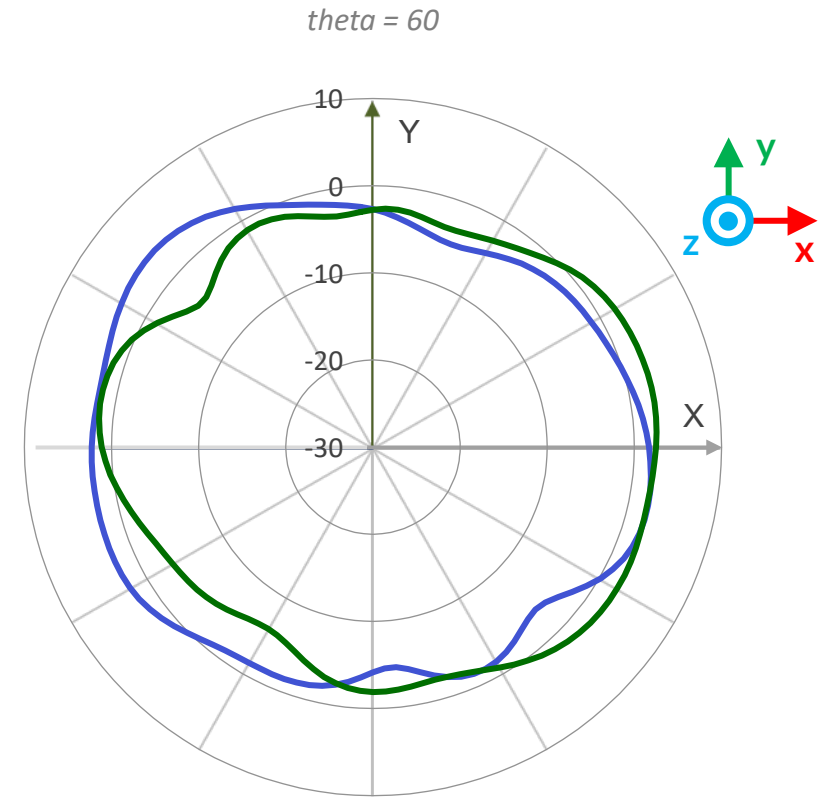
Scanning @2450MHz for Gtotal



— SC1 — SC2



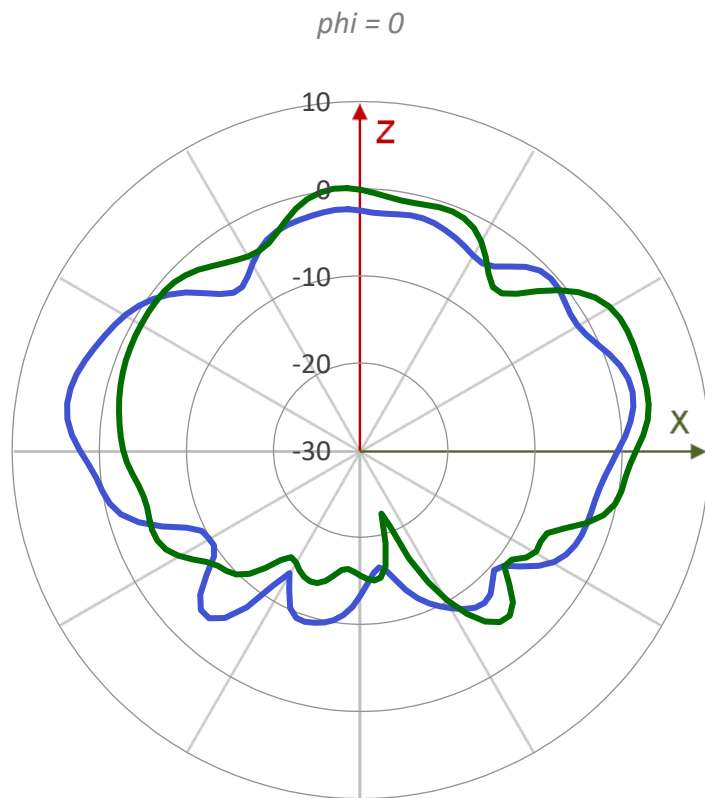
— SC1 — SC2



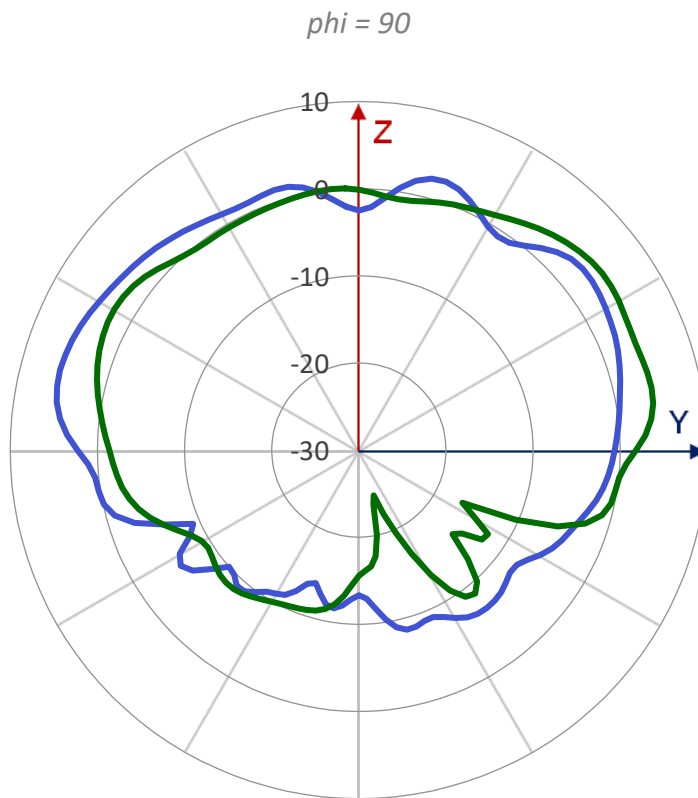
— SC1 — SC2

# Realized Gain Pattern

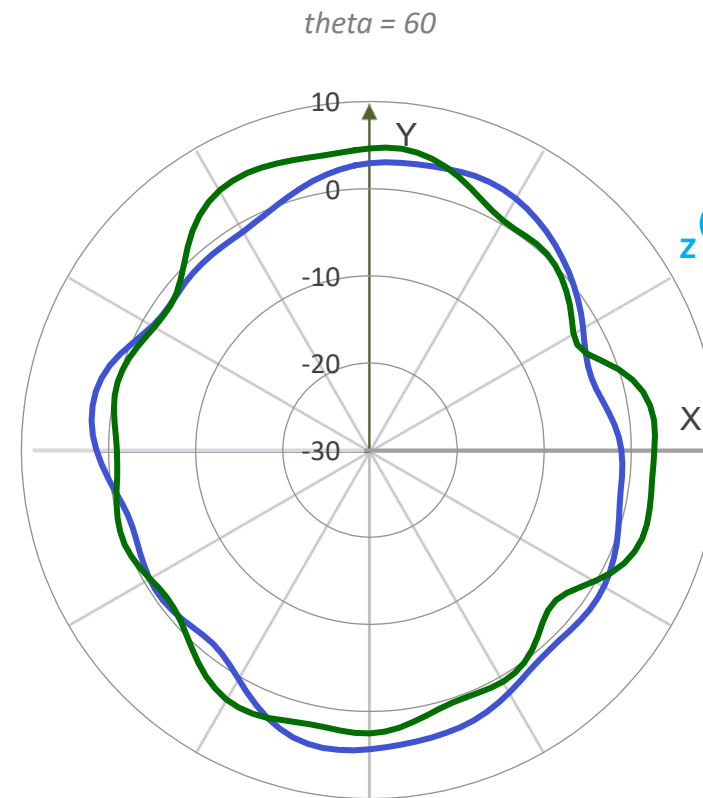
Scanning @5450MHz for Gtotal



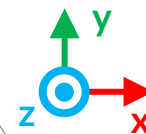
— SC1 — SC2



— SC1 — SC2

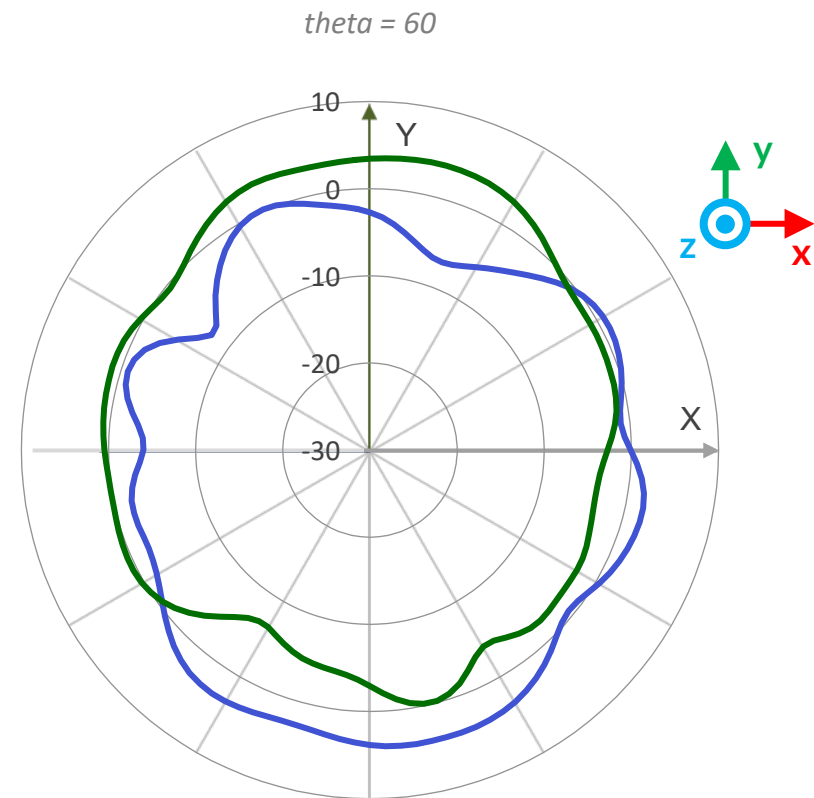
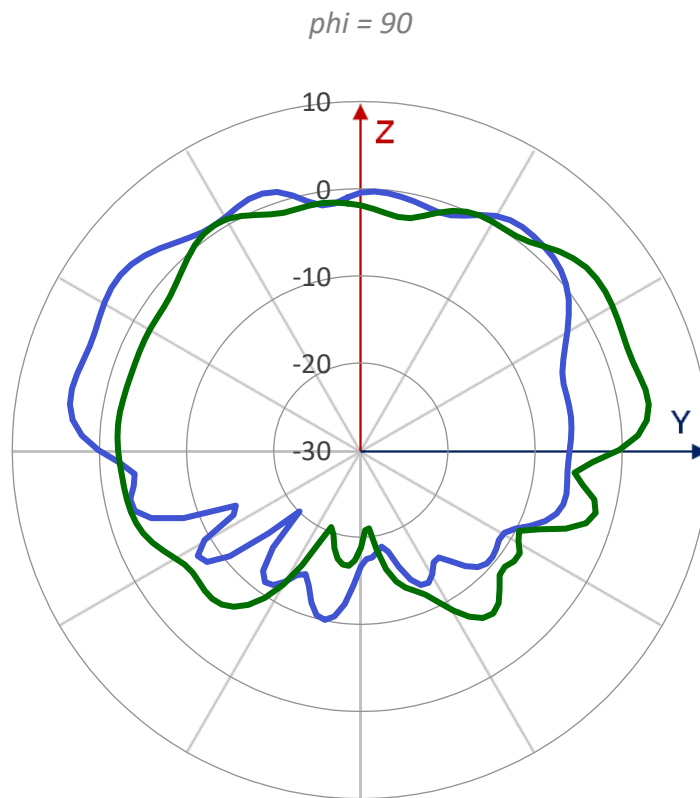
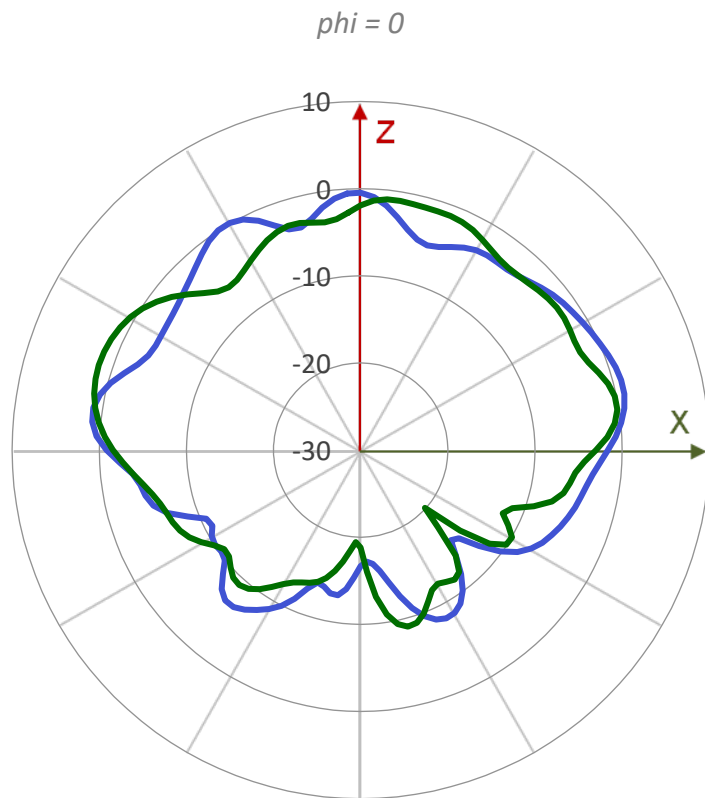


— SC1 — SC2



# Realized Gain Pattern

Scanning @6565MHz for Gtotal



# Zigbee(Thread)



- **Maximum VSWR**

- 1.5:1 on 2.4GHz

- **Average Efficiency**

- ~68% on 2.4GHz

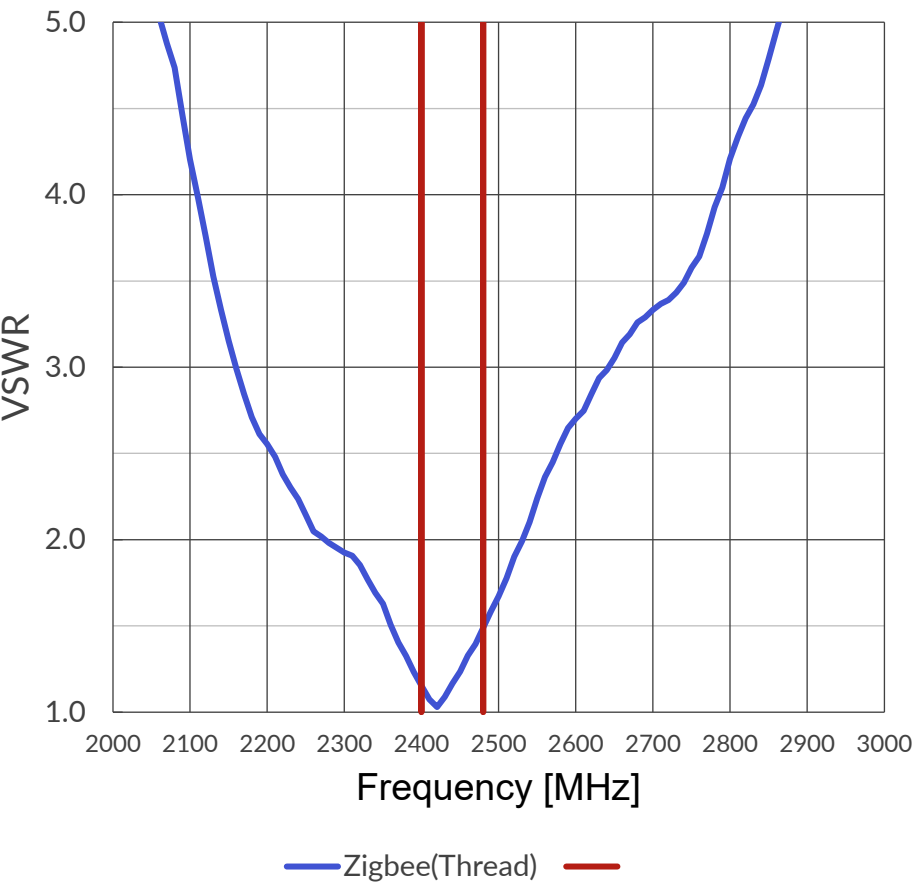
- **Peak Gain**

- 3.9dBi on 2.4GHz

- **Cable Length**

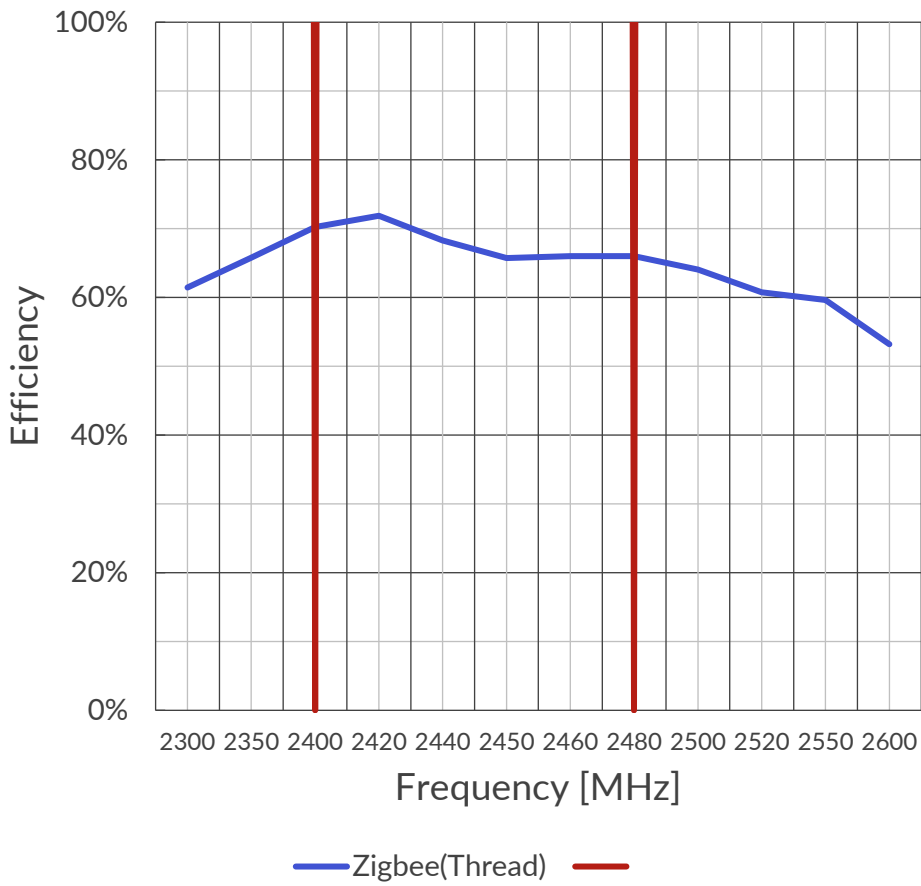
Zigbee(Thread) : 232mm

# VSWR Zigbee(Thread)



| 2.4GHz         | Max | Mean | Min |
|----------------|-----|------|-----|
| Zigbee(Thread) | 1.5 | 1.2  | 1.0 |

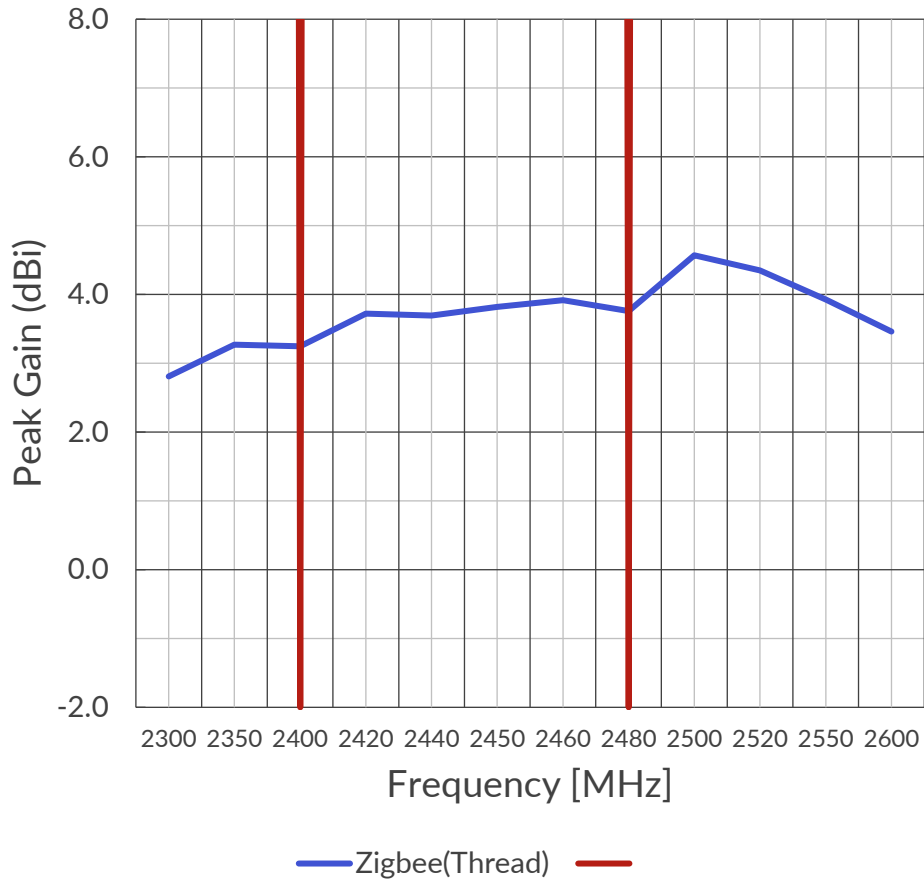
# Efficiency Zigbee(Thread)



| 2.4GHz         | Max  | Mean | Min  |
|----------------|------|------|------|
| Zigbee(Thread) | 70 % | 68 % | 66 % |

■ Cable Length  
Zigbee(Thread) : 232mm

# Peak Gain Zigbee(Thread)



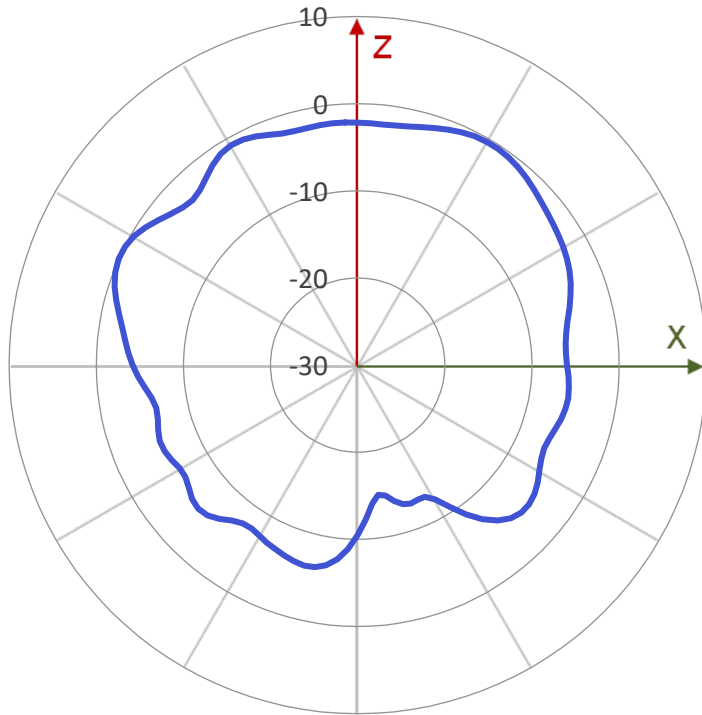
| 2.4GHz         | Max     | Mean    | Min     |
|----------------|---------|---------|---------|
| Zigbee(Thread) | 3.9 dBi | 3.7 dBi | 3.2 dBi |

■ Cable Length

Zigbee(Thread) : 232mm

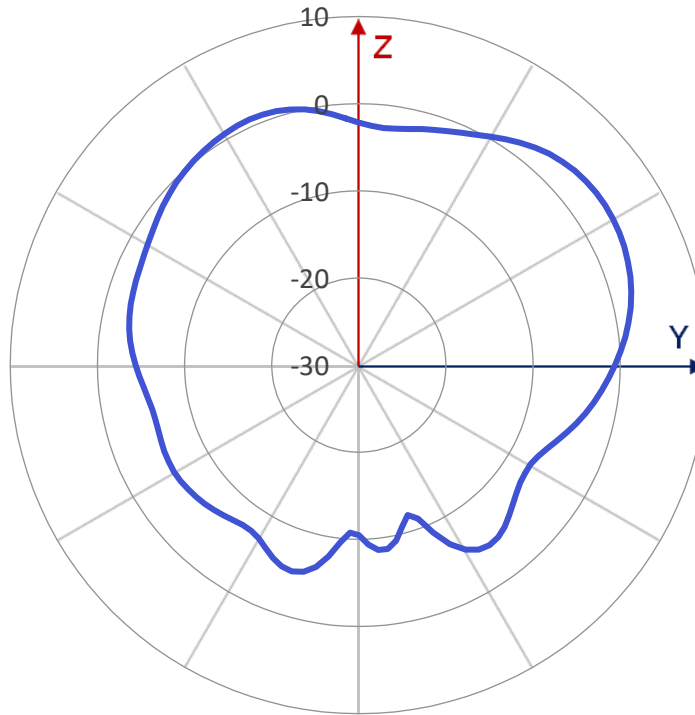
# Realized Gain Pattern Zigbee(Thread) @2440MHz for Gtotal

$\phi = 0$



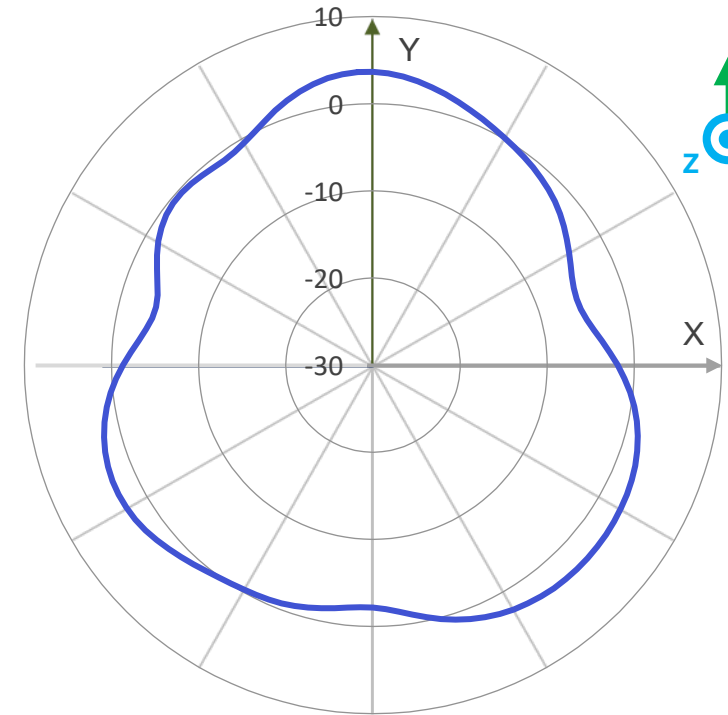
— Zigbee(Thread)

$\phi = 90$

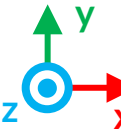


— Zigbee(Thread)

$\theta = 60$



— Zigbee(Thread)



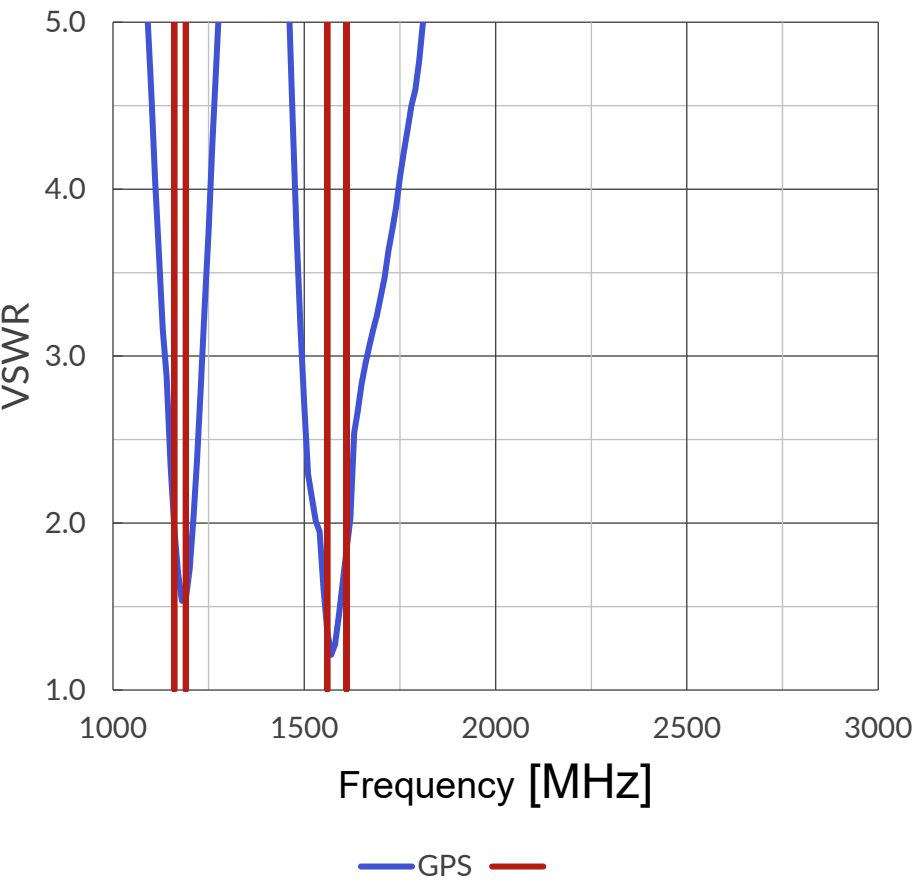
# GPS



- **Maximum VSWR**
  - 1.8:1 on L1 / 2.0:1 on L5
- **Minimum Isolation**
  - 23.9dB on 2.4GHz
- **Average Efficiency**
  - ~59% on L1 / ~61% on L5
- **Peak Gain**
  - 2.6dBi on L1 / 2.9dBi on L5

- **Cable Length**  
GPS : 314mm

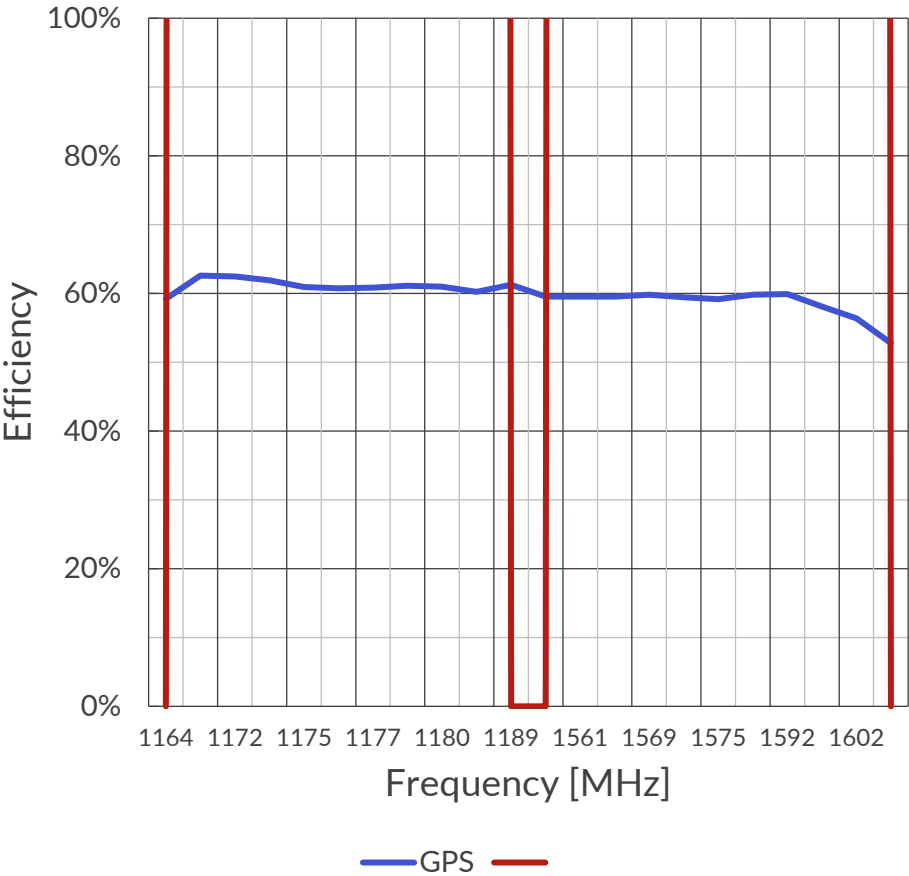
# VSWR GPS



| L1  | Max | Mean | Min |
|-----|-----|------|-----|
| GPS | 1.8 | 1.5  | 1.2 |

| L5  | Max | Mean | Min |
|-----|-----|------|-----|
| GPS | 2.0 | 1.7  | 1.5 |

# Efficiency GPS



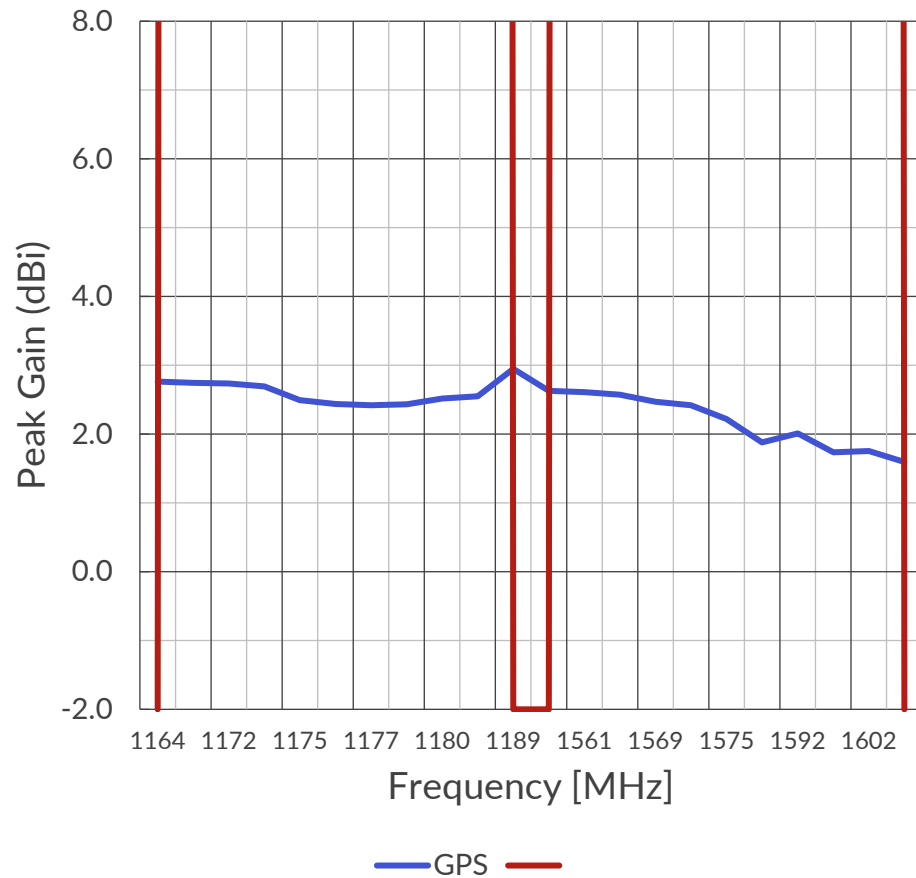
| L1  | Max  | Mean | Min  |
|-----|------|------|------|
| GPS | 60 % | 59 % | 53 % |

| L5  | Max  | Mean | Min  |
|-----|------|------|------|
| GPS | 63 % | 61 % | 59 % |

■ Cable Length

GPS : 314mm

# Peak Gain **GPS**

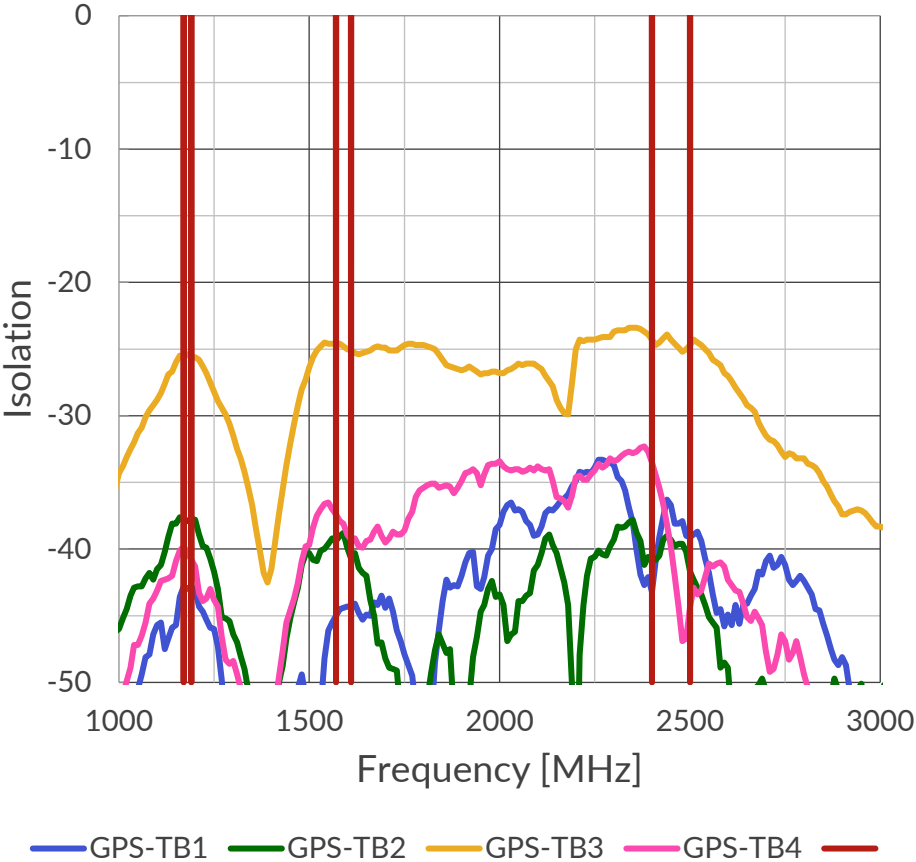


| L1  | Max     | Mean    | Min     |
|-----|---------|---------|---------|
| GPS | 2.6 dBi | 2.2 dBi | 1.6 dBi |

| L5  | Max     | Mean    | Min     |
|-----|---------|---------|---------|
| GPS | 2.9 dBi | 2.6 dBi | 2.4 dBi |

■ Cable Length  
GPS : 314mm

# Isolation



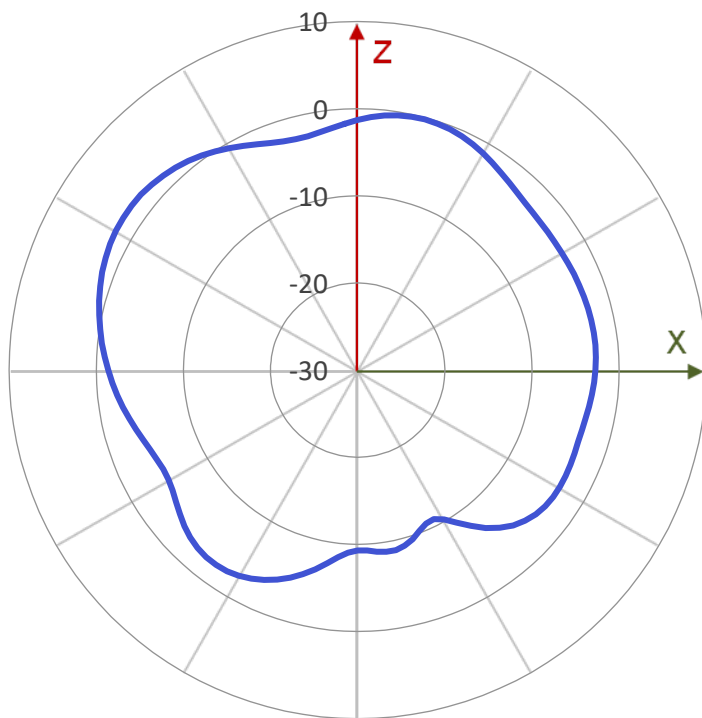
| L1      | Max   | Mean  | Min   |
|---------|-------|-------|-------|
| GPS-TB1 | -44.3 | -44.5 | -45.0 |
| GPS-TB2 | -38.8 | -39.6 | -40.7 |
| GPS-TB3 | -24.6 | -24.8 | -25.1 |
| GPS-TB4 | -37.4 | -38.3 | -39.3 |
| Summary | -24.6 | -36.9 | -45.0 |

| L5      | Max   | Mean  | Min   |
|---------|-------|-------|-------|
| GPS-TB1 | -42.8 | -42.9 | -43.0 |
| GPS-TB2 | -37.7 | -37.8 | -37.9 |
| GPS-TB3 | -25.4 | -25.5 | -25.6 |
| GPS-TB4 | -39.8 | -40.3 | -40.8 |
| Summary | -25.4 | -36.6 | -43.0 |

| 2.4GHz  | Max   | Mean  | Min   |
|---------|-------|-------|-------|
| GPS-TB1 | -36.3 | -38.7 | -43.2 |
| GPS-TB2 | -39.0 | -40.0 | -41.7 |
| GPS-TB3 | -23.9 | -24.6 | -25.2 |
| GPS-TB4 | -33.5 | -40.2 | -46.9 |
| Summary | -23.9 | -35.9 | -46.9 |

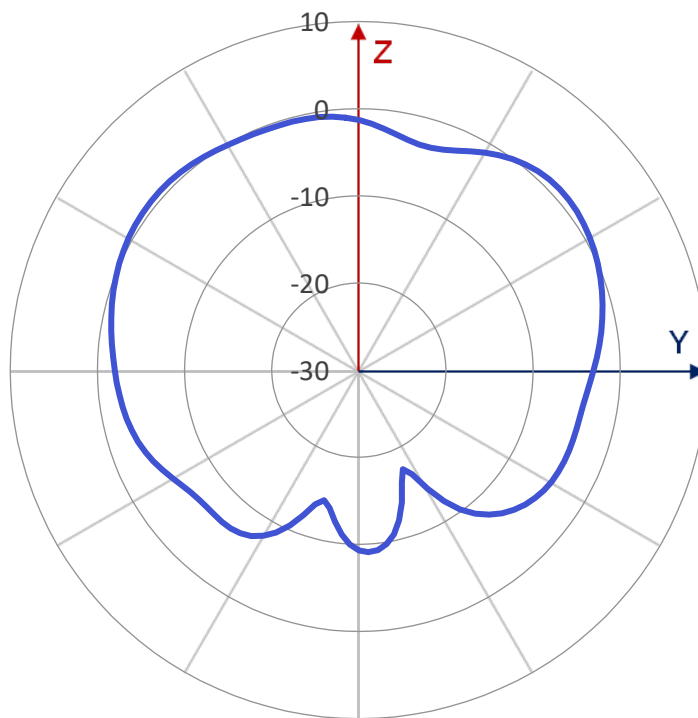
# Realized Gain Pattern GPS @1575MHz for Gtotal

$\phi = 0$



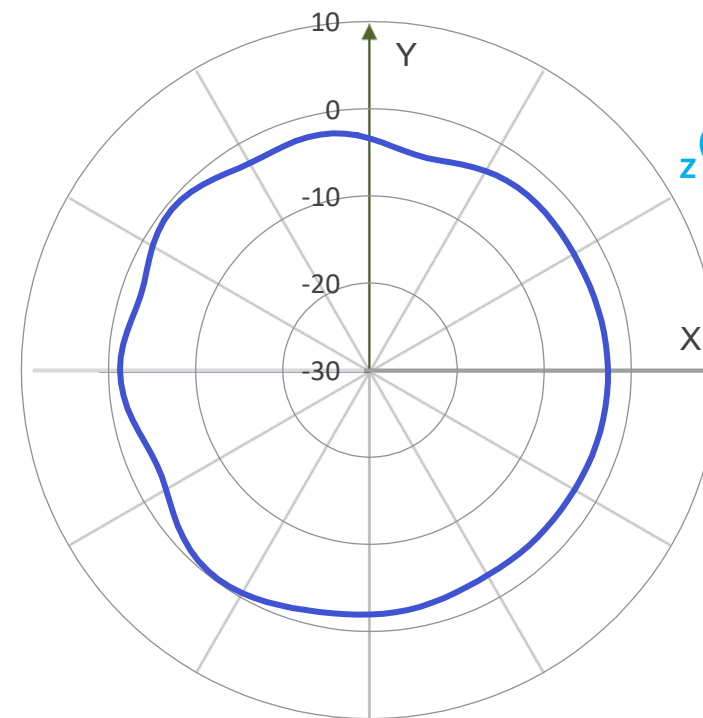
— GPS

$\phi = 90$

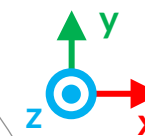


— GPS

$\theta = 90$

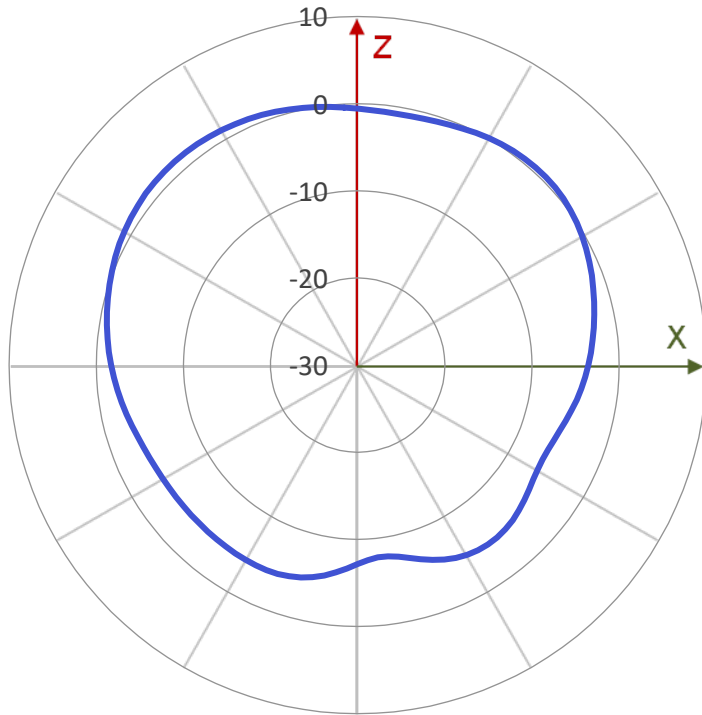


— GPS



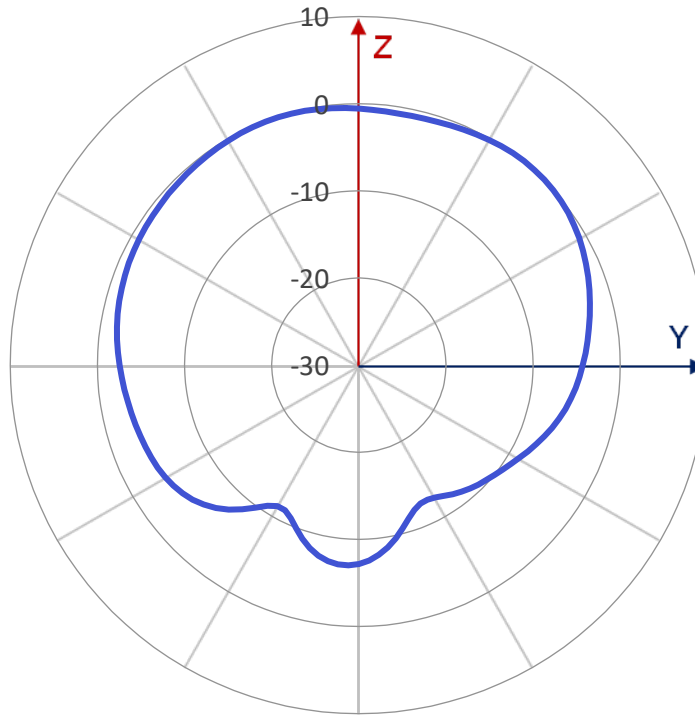
# Realized Gain Pattern GPS @1176MHz for Gtotal

$\phi = 0$



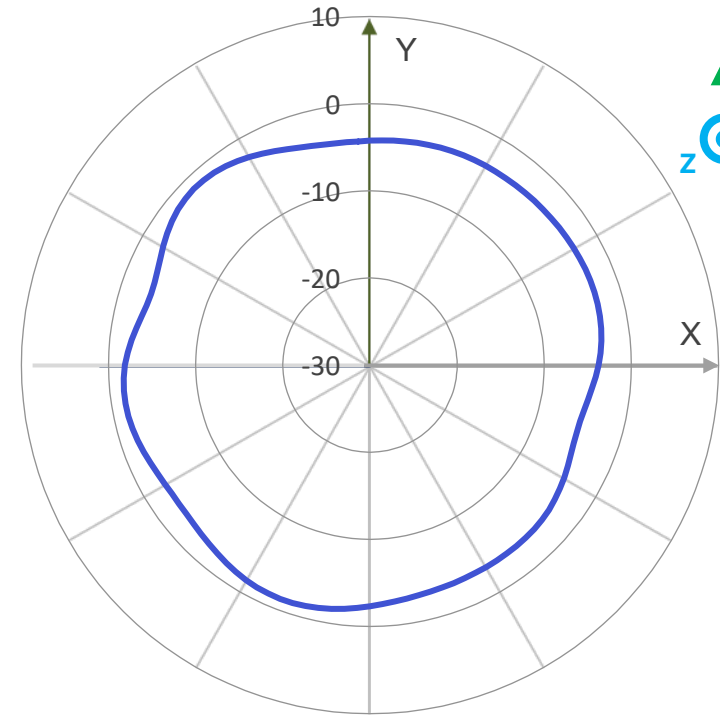
— GPS

$\phi = 90$

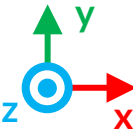


— GPS

$\theta = 90$



— GPS



# UWB\_TWR



## ■ Maximum VSWR

- 3.4:1 on Ch5 / 1.5:1 on Ch9

## ■ Average Efficiency

- ~41% on Ch5 / ~61% on Ch9

## ■ Peak Gain

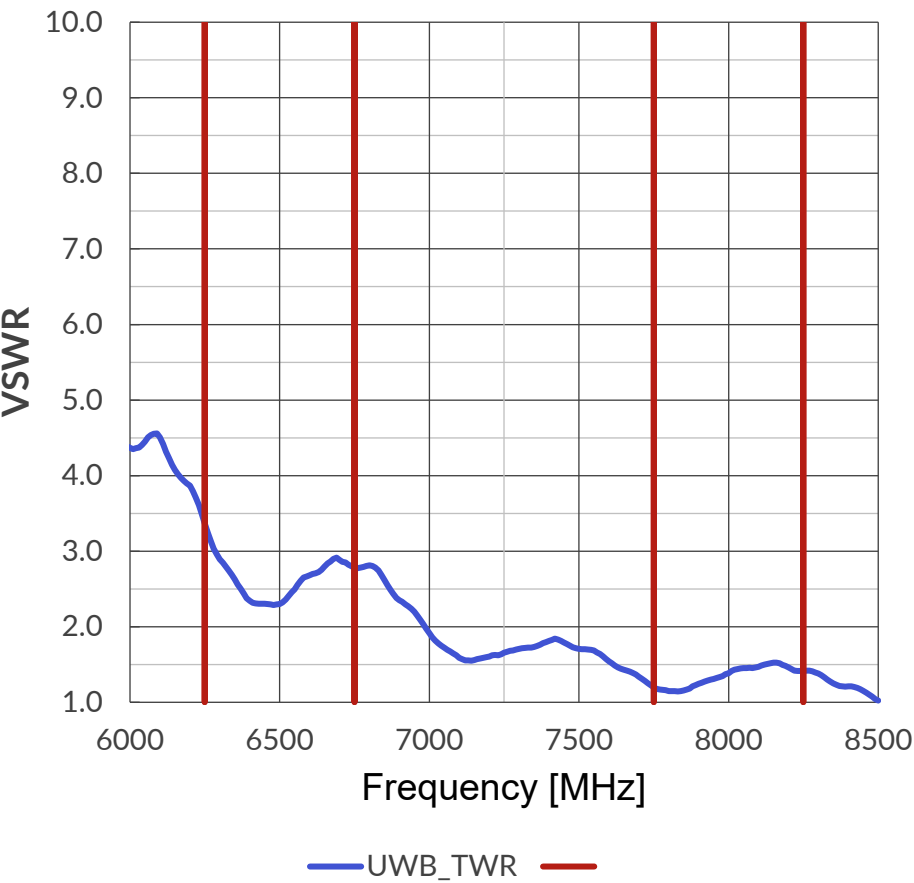
- 4.2dBi on Ch5 / 4.7dBi on Ch9

## ■ Cable Length

UWB-TWR : 142mm

# VSWR

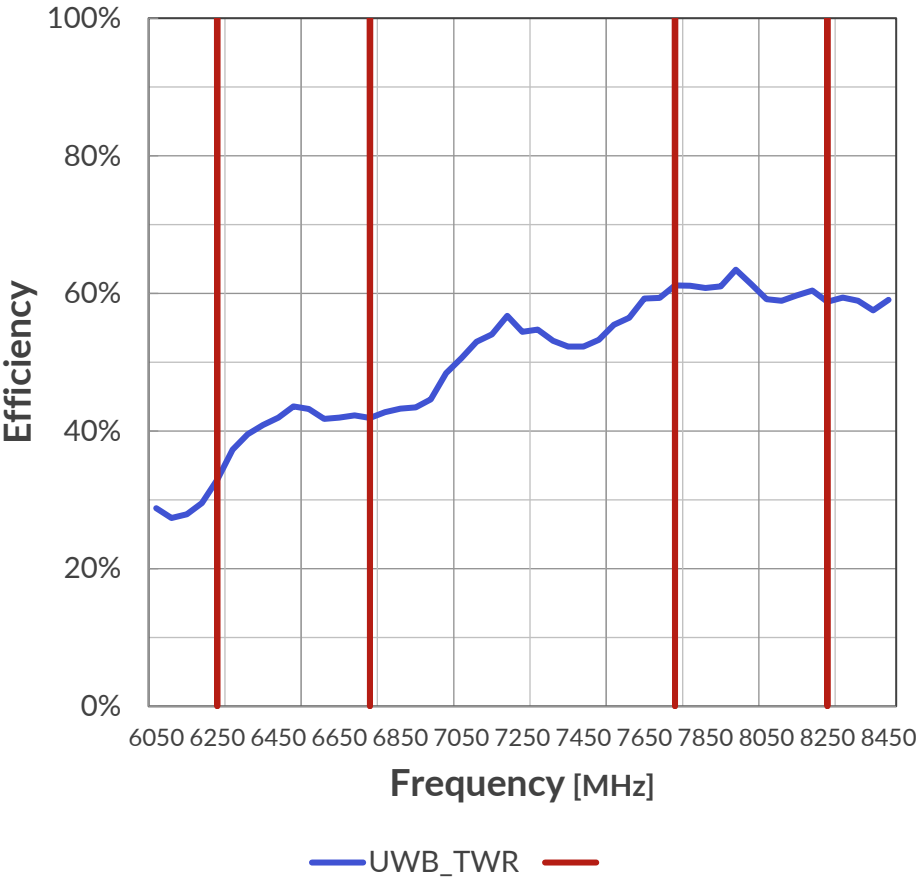
## UWB\_TWR



| Ch5     | Max | Mean | Min |
|---------|-----|------|-----|
| UWB_TWR | 3.4 | 2.6  | 2.3 |

| Ch9     | Max | Mean | Min |
|---------|-----|------|-----|
| UWB_TWR | 1.5 | 1.3  | 1.1 |

# Efficiency **UWB\_TWR**

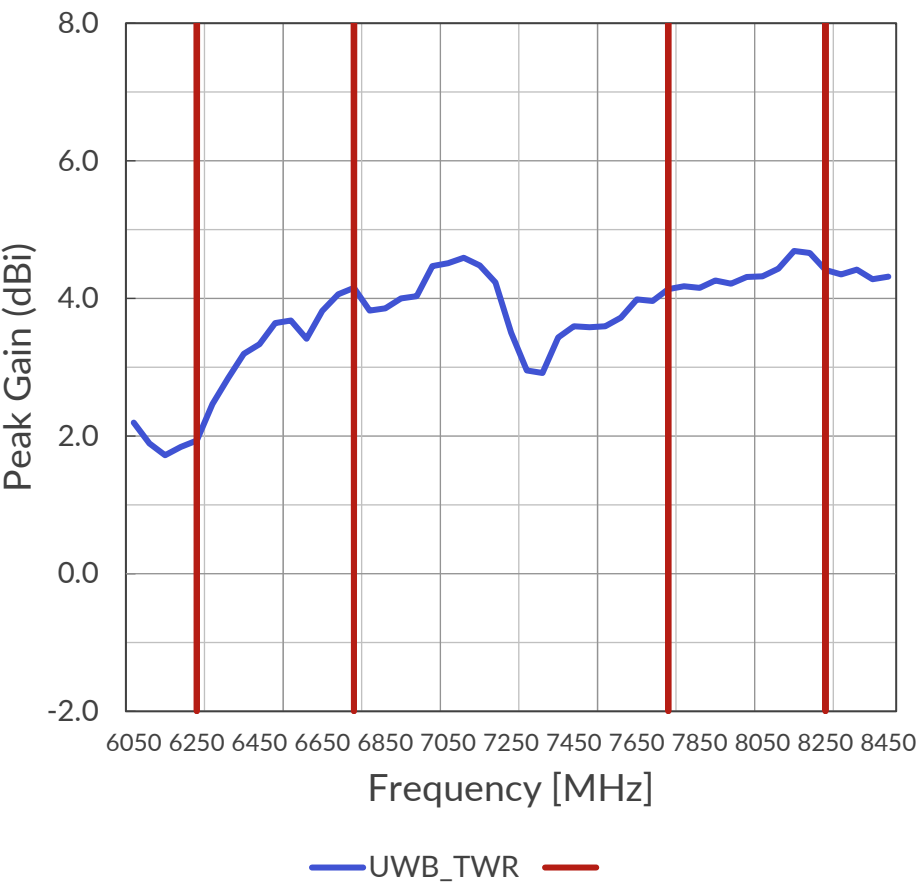


| Ch5 | Max  | Mean | Min  |
|-----|------|------|------|
| TWR | 44 % | 41 % | 33 % |

| Ch9 | Max  | Mean | Min  |
|-----|------|------|------|
| TWR | 63 % | 61 % | 59 % |

■ Cable Length  
UWB\_TWR : 142mm

# Peak Gain UWB\_TWR



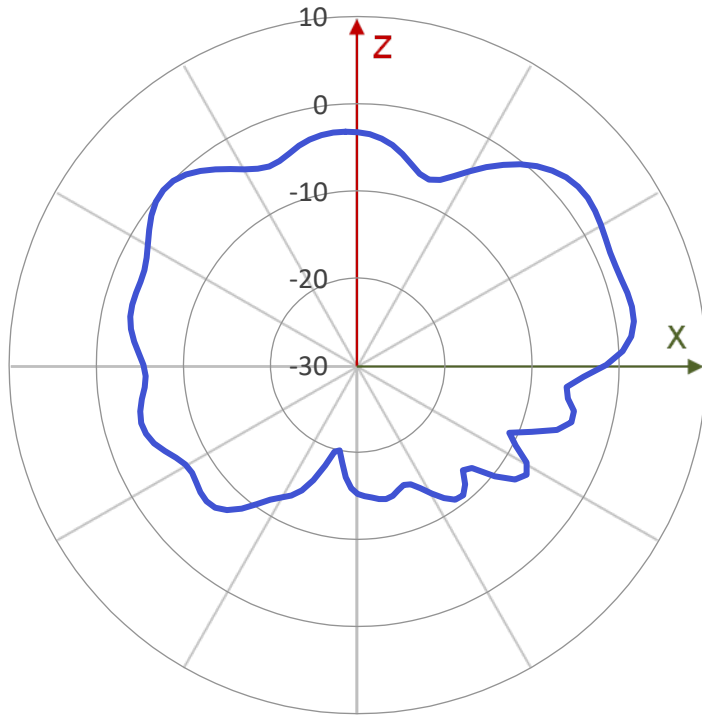
| Ch5     | Max     | Mean    | Min     |
|---------|---------|---------|---------|
| UWB_TWR | 4.2 dBi | 3.3 dBi | 1.9 dBi |

| Ch9     | Max     | Mean    | Min     |
|---------|---------|---------|---------|
| UWB_TWR | 4.7 dBi | 4.3 dBi | 4.1 dBi |

■ Cable Length  
UWB\_TWR : 142mm

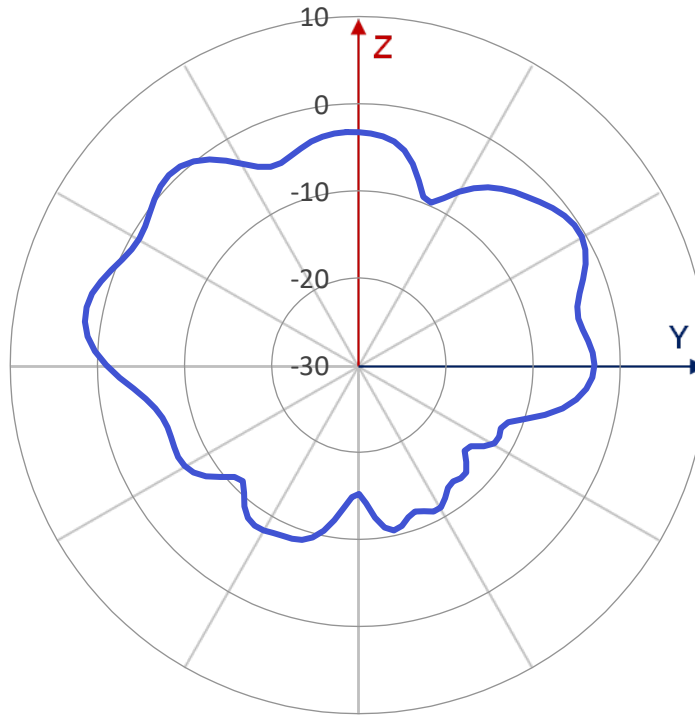
# Realized Gain Pattern UWB\_TWR@6500MHz for Gtotal

$\phi = 0$



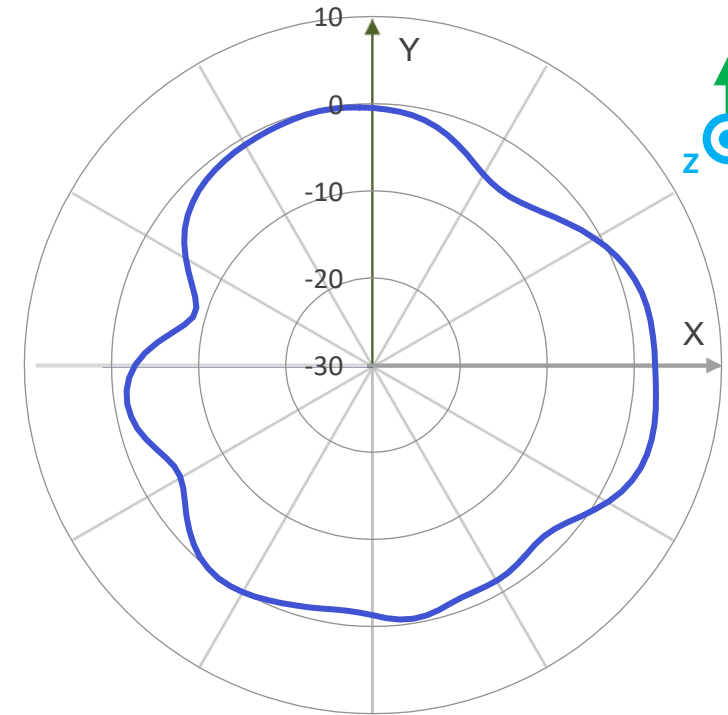
—UWB\_TWR

$\phi = 90$

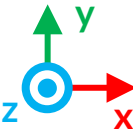


—UWB\_TWR

$\theta = 60$

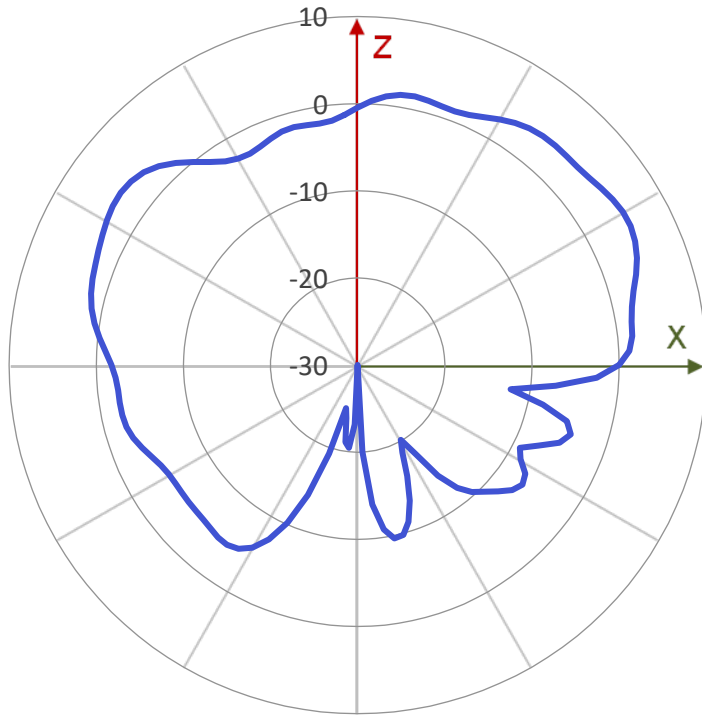


—UWB\_TWR



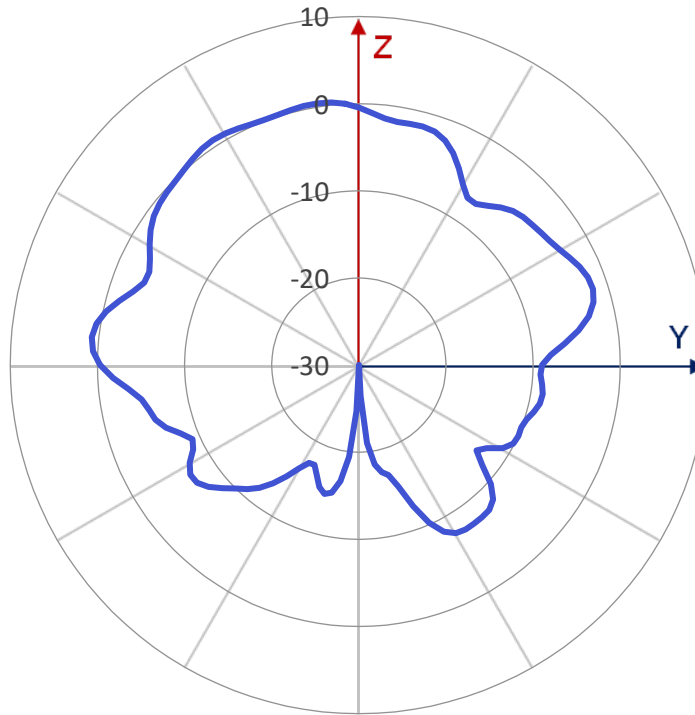
# Realized Gain Pattern UWB\_TWR @8000MHz for Gtotal

$\phi = 0$



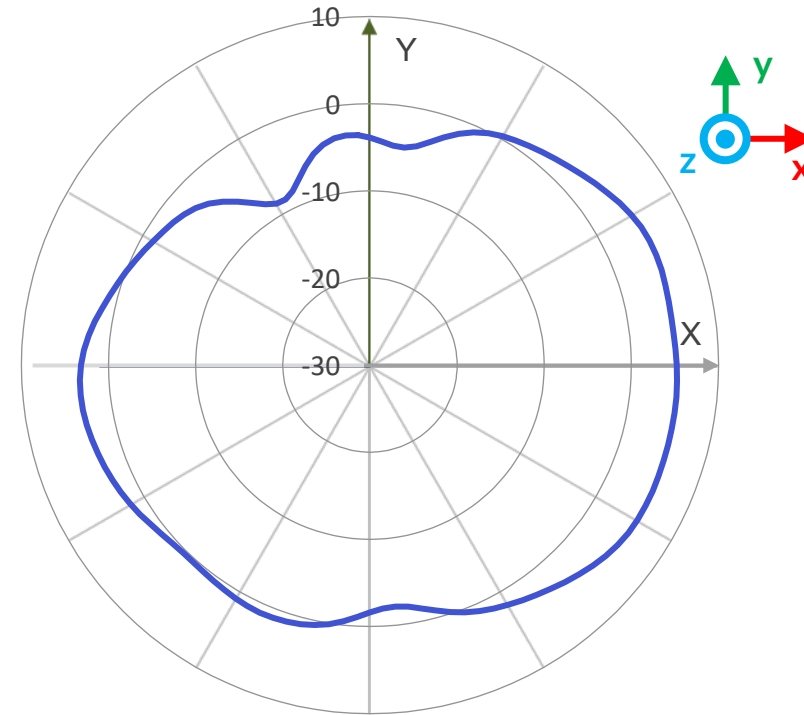
—UWB\_TWR

$\phi = 90$



—UWB\_TWR

$\theta = 60$



—UWB\_TWR

# UWB\_PDoA



- **Maximum VSWR**

- 2.7:1 on Ch9

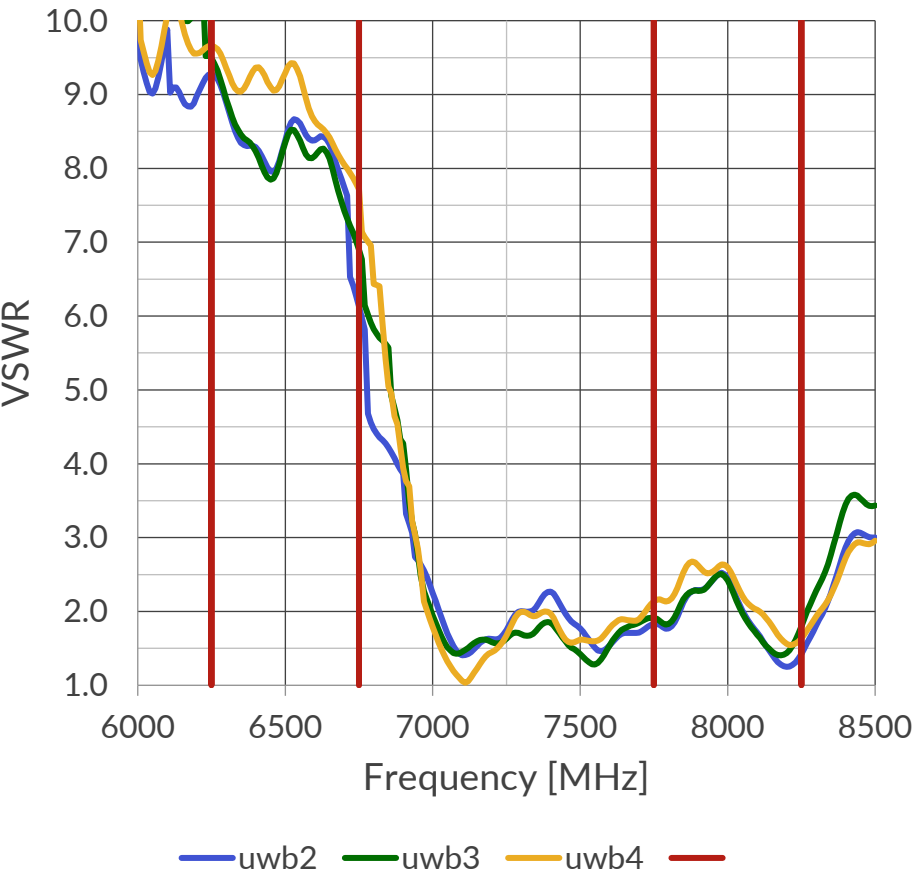
- **Average Efficiency**

- ~19% on Ch9

- **Peak Gain**

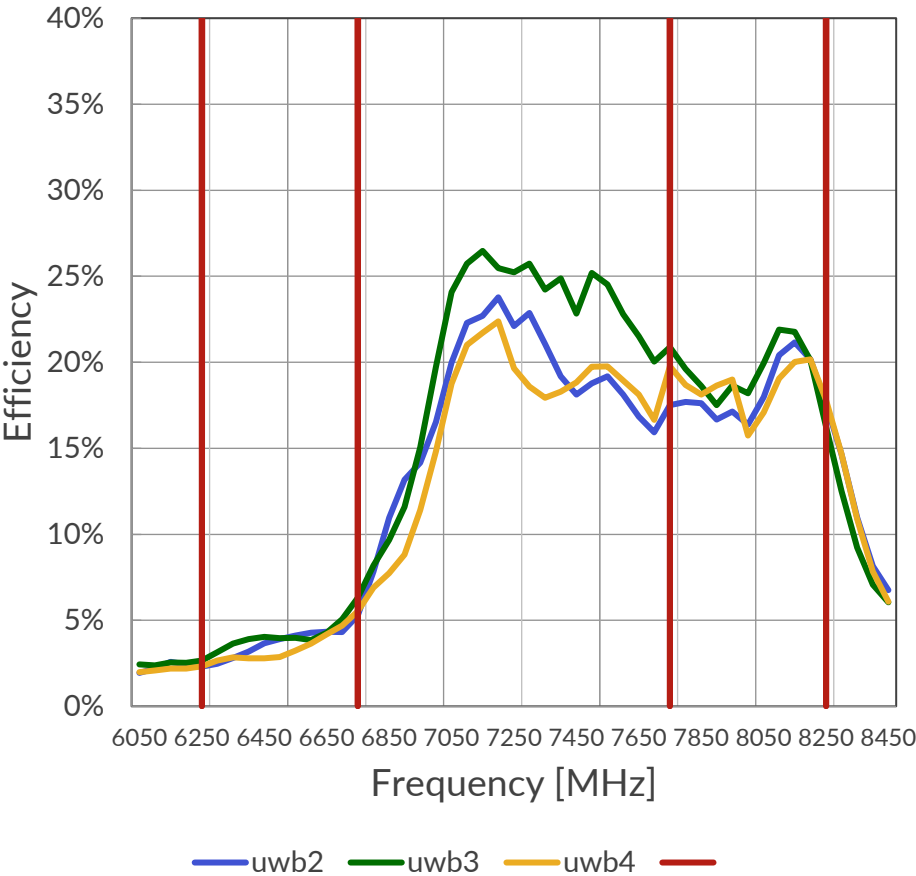
- 1.8dBi on Ch9

# VSWR UWB\_PDoA



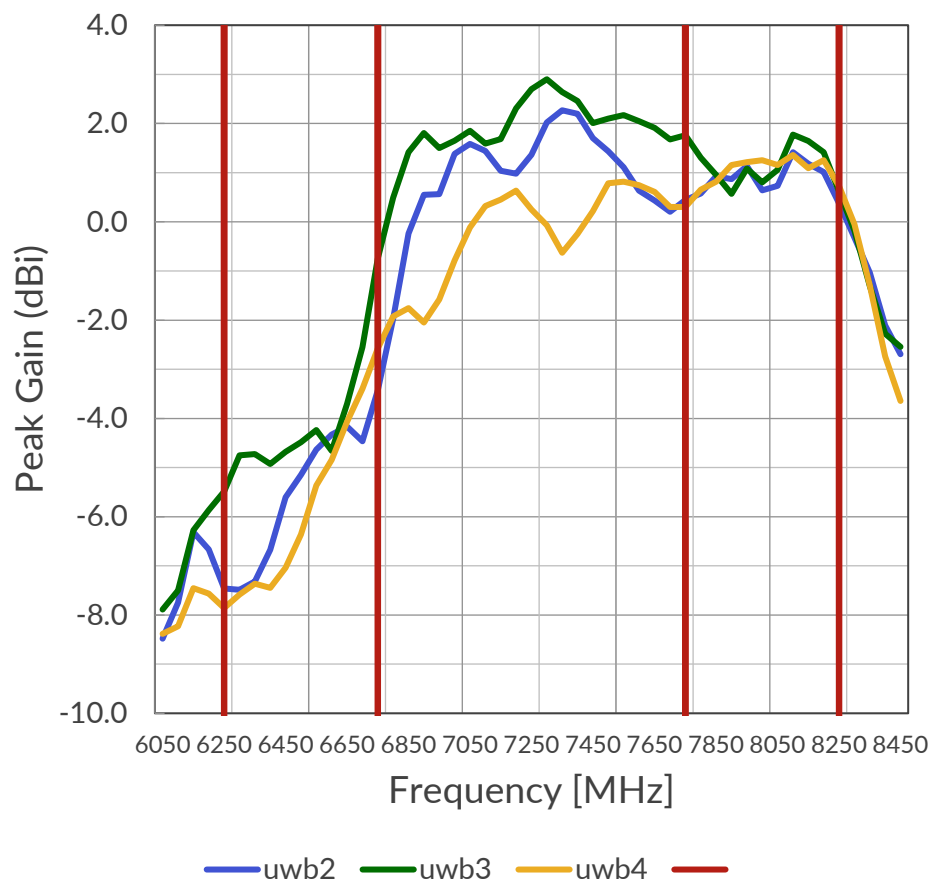
| Ch9     | Max | Mean | Min |
|---------|-----|------|-----|
| uwb2    | 2.5 | 1.9  | 1.3 |
| uwb3    | 2.5 | 1.9  | 1.4 |
| uwb4    | 2.7 | 2.1  | 1.5 |
| Summary | 2.7 | 2.0  | 1.3 |

# Efficiency UWB\_PDoA



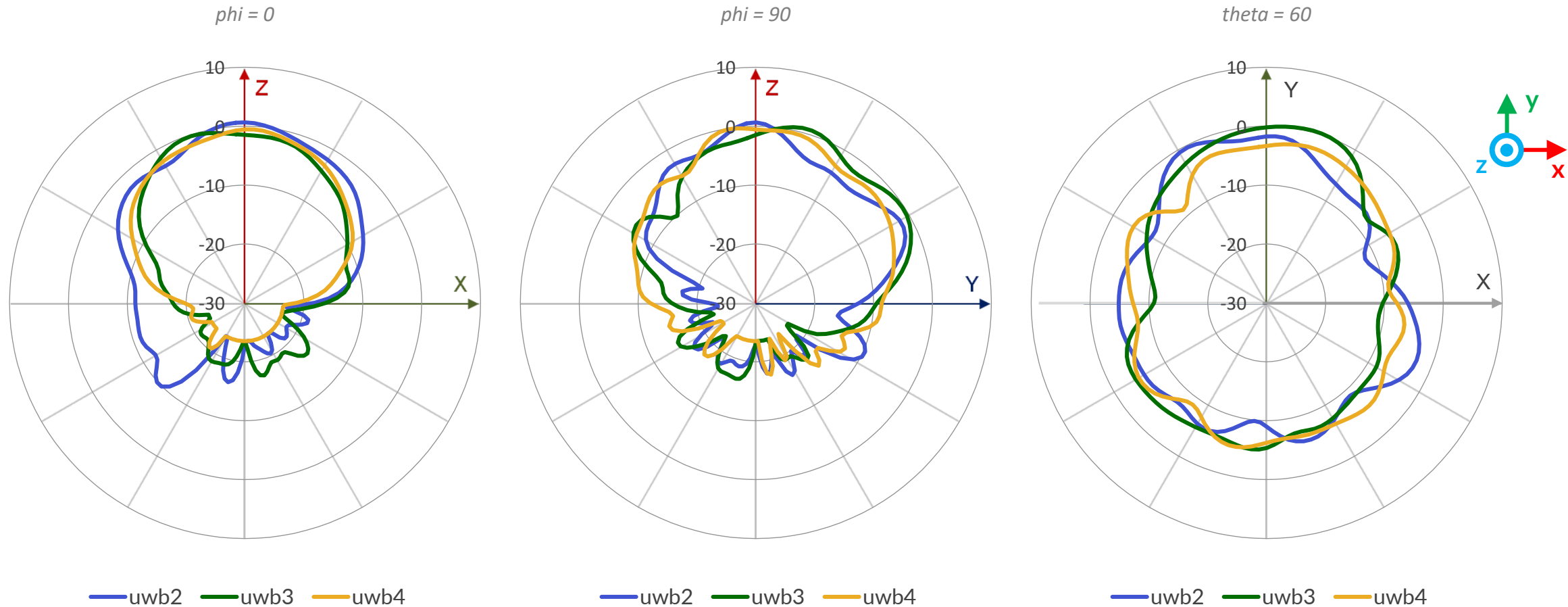
| Ch9     | Max  | Mean | Min  |
|---------|------|------|------|
| uwb2    | 21 % | 18 % | 16 % |
| uwb3    | 22 % | 19 % | 16 % |
| uwb4    | 20 % | 19 % | 16 % |
| Summary | 22 % | 19 % | 16 % |

# Peak Gain UWB\_PDoA



| Ch9     | Max     | Mean    | Min     |
|---------|---------|---------|---------|
| uwb2    | 1.4 dBi | 0.8 dBi | 0.4 dBi |
| uwb3    | 1.8 dBi | 1.2 dBi | 0.6 dBi |
| uwb4    | 1.4 dBi | 1.0 dBi | 0.3dBi  |
| Summary | 1.8 dBi | 1.0 dBi | 0.3 dBi |

# Realized Gain Pattern UWB\_PDoA @8000MHz for Gtotal



# Isolation among Radios

- **Wi-Fi 5G to Wi-Fi Tri-Band**

- 41.6dB on 2.4GHz / 35.7dB on 5-7GHz

- **Wi-Fi 6G to Wi-Fi Tri-Band**

- 36.3dB on 2.4GHz / 30.0dB on 5-7GHz

- **Wi-Fi 6G to Wi-Fi 5G**

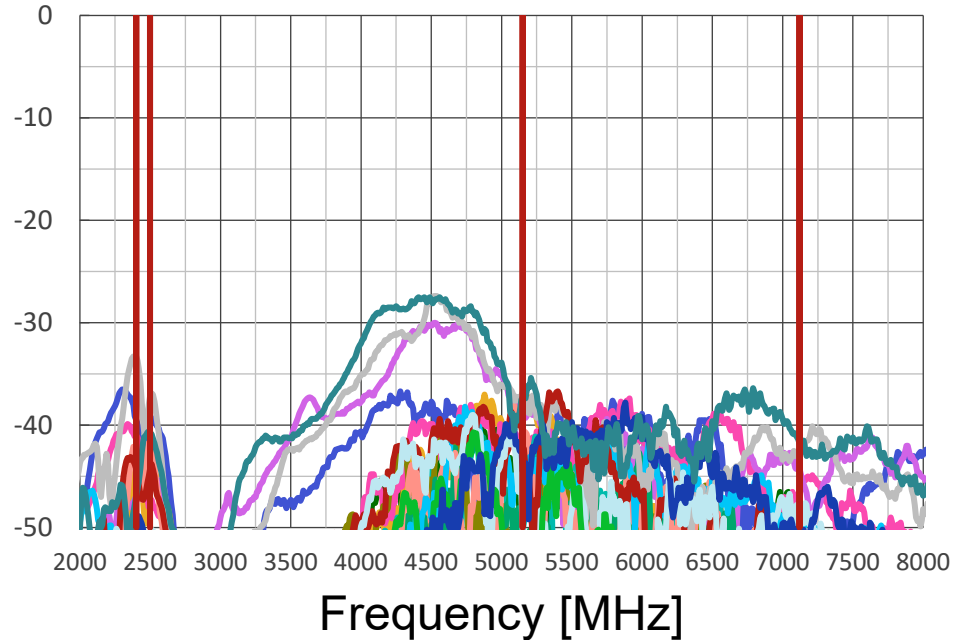
- 31dB on 5-7GHz

- **UWB-TWR to Wi-Fi Radios**

- 26.7dB on 5GHz / 27.8dB on 6GHz / 25.9dB on Ch9

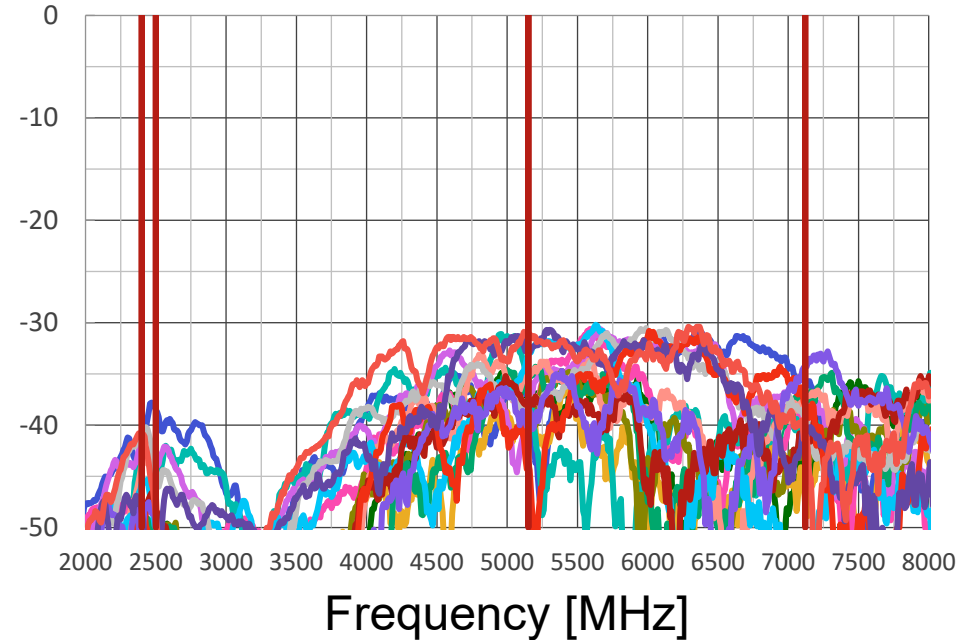
# Isolation Wi-Fi 5G to Wi-Fi Tri-Band / Wi-Fi 6G to Wi-Fi Tri-Band

## ➤ Wi-Fi 5G to Wi-Fi Tri-Band



5G1-TB1 5G1-TB2 5G1-TB3 5G1-TB4  
5G2-TB1 5G2-TB2 5G2-TB3 5G2-TB4  
5G3-TB1 5G3-TB2 5G3-TB3 5G3-TB4  
5G4-TB1 5G4-TB2 5G4-TB3 5G4-TB4

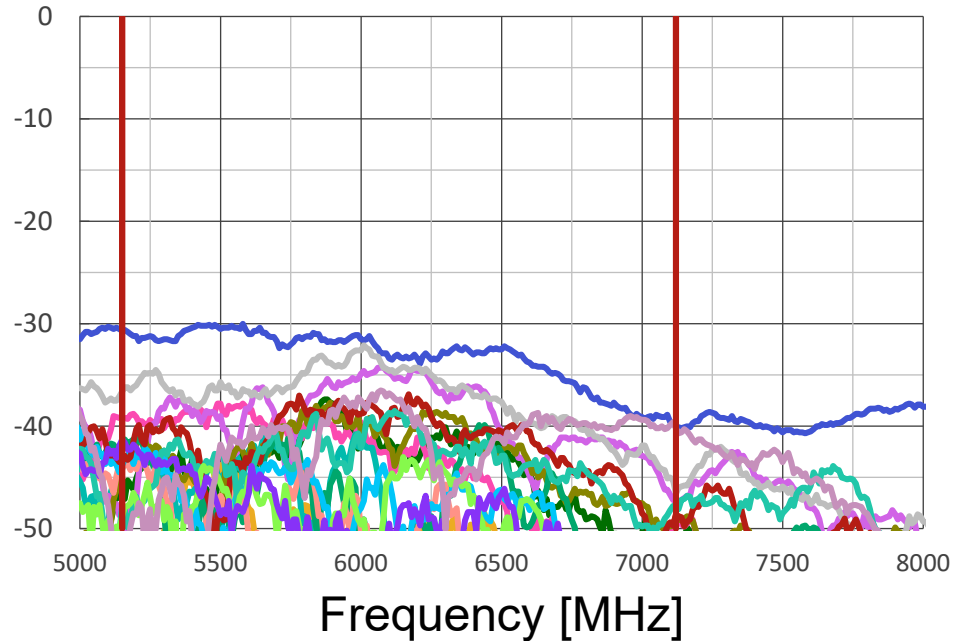
## ➤ Wi-Fi 6G to Wi-Fi Tri-Band



6G1-TB1 6G1-TB2 6G1-TB3 6G1-TB4  
6G2-TB1 6G2-TB2 6G2-TB3 6G2-TB4  
6G3-TB1 6G3-TB2 6G3-TB3 6G3-TB4  
6G4-TB1 6G4-TB2 6G4-TB3 6G4-TB4

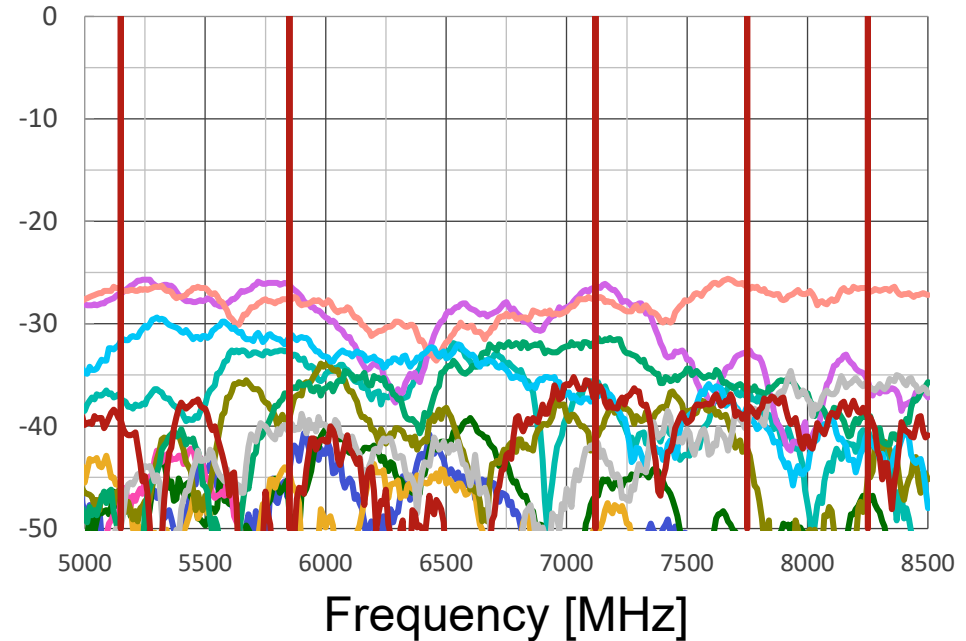
# Isolation Wi-Fi 5G to Wi-Fi 6G / UWB - TWR to Wi-Fi Radios

## ➤ Wi-Fi 5G to Wi-Fi 6G



5G1-6G1 5G1-6G2 5G1-6G3 5G1-6G4  
5G2-6G1 5G2-6G2 5G2-6G3 5G2-6G4  
5G3-6G1 5G3-6G2 5G3-6G3 5G3-6G4  
5G4-6G1 5G4-6G2 5G4-6G3 5G4-6G4

## ➤ UWB - TWR to Wi-Fi Radios



UWB\_TWR-5G1 UWB\_TWR-5G2 UWB\_TWR-5G3  
UWB\_TWR-5G4 UWB\_TWR-6G1 UWB\_TWR-6G2  
UWB\_TWR-6G3 UWB\_TWR-6G4 UWB\_TWR-TB1  
UWB\_TWR-TB2 UWB\_TWR-TB3 UWB\_TWR-TB4

# BLE Array – Directional Beam



## ■ Efficiency

- ~16% on 2.4GHz [Beam1~Beam8]
- ~27% on 2.4GHz [Beam9]

## ■ Peak Gain

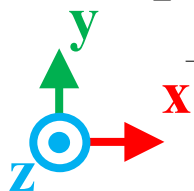
- 4.2dBi on 2.4GHz [Beam1~Beam8]
- 3.0dBi on 2.4GHz [Beam9]

## ■ Beam Width

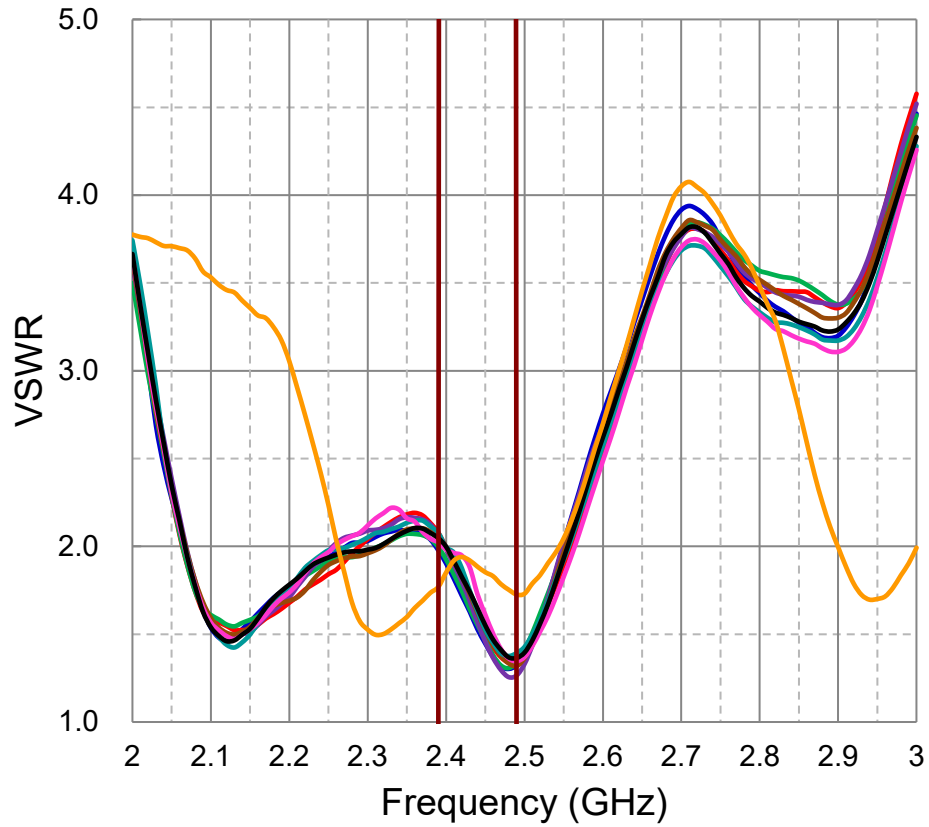
- ~48° on 2.4GHz [Beam1~Beam8]

## ■ Front to Back Ratio

- ~12.0dB on 2.4GHz [Beam1~Beam8]



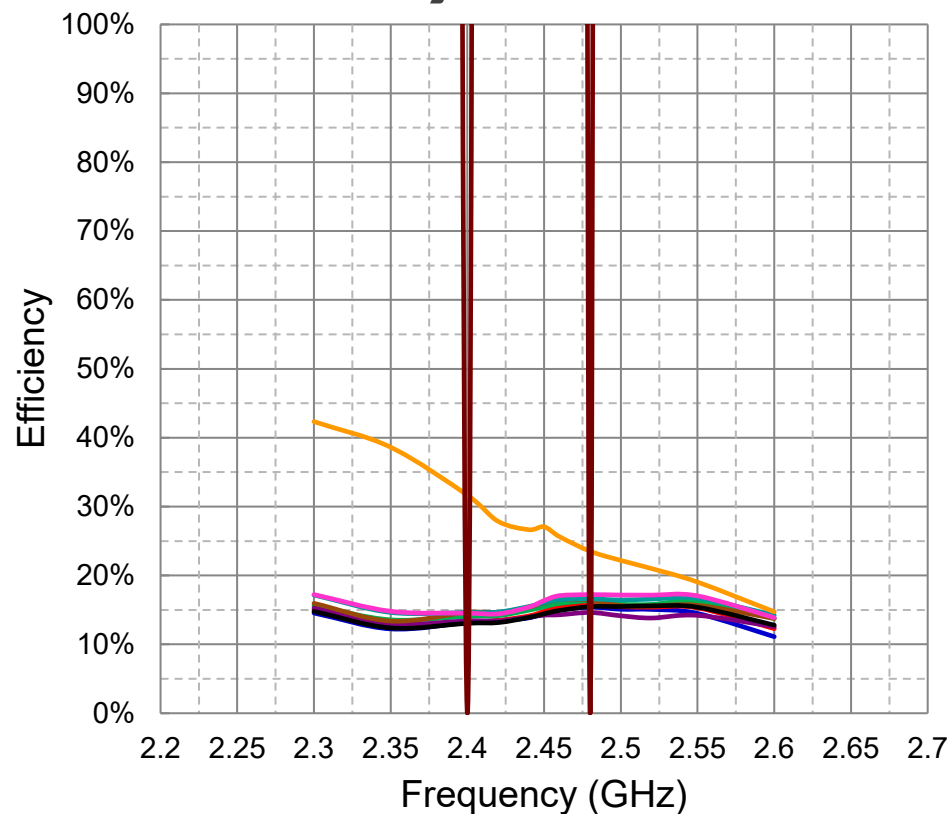
# VSWR Directional Beam



— Beam1    — Beam2    — Beam3    — Beam4    — Beam5  
— Beam6    — Beam7    — Beam8    — Beam9    —

| 2.4GHz | Max | Mean | Min |
|--------|-----|------|-----|
| Beam 1 | 1.9 | 1.6  | 1.3 |
| Beam 2 | 2.0 | 1.6  | 1.3 |
| Beam 3 | 1.9 | 1.6  | 1.3 |
| Beam 4 | 2.0 | 1.6  | 1.3 |
| Beam 5 | 2.0 | 1.6  | 1.3 |
| Beam 6 | 2.0 | 1.7  | 1.4 |
| Beam 7 | 2.0 | 1.7  | 1.4 |
| Beam 8 | 2.0 | 1.7  | 1.4 |
| Beam 9 | 1.9 | 1.9  | 1.8 |

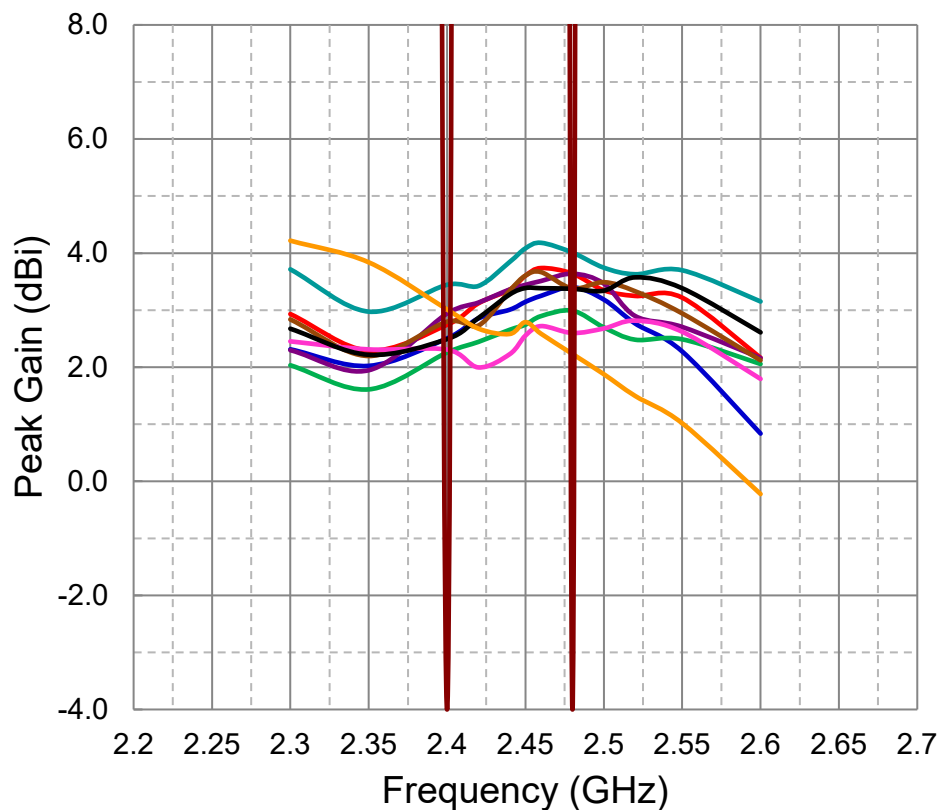
# Efficiency Directional Beam



— Beam1    — Beam2    — Beam3    — Beam4    — Beam5  
— Beam6    — Beam7    — Beam8    — Beam9    —

| 2.4GHz | Max  | Mean | Min  |
|--------|------|------|------|
| Beam 1 | 15 % | 14 % | 13 % |
| Beam 2 | 16 % | 14 % | 13 % |
| Beam 3 | 16 % | 15 % | 14 % |
| Beam 4 | 15 % | 14 % | 13 % |
| Beam 5 | 16 % | 16 % | 15 % |
| Beam 6 | 17 % | 16 % | 15 % |
| Beam 7 | 17 % | 16 % | 14 % |
| Beam 8 | 15 % | 14 % | 13 % |
| Beam 9 | 32 % | 27 % | 24 % |

# Peak Gain Directional Beam

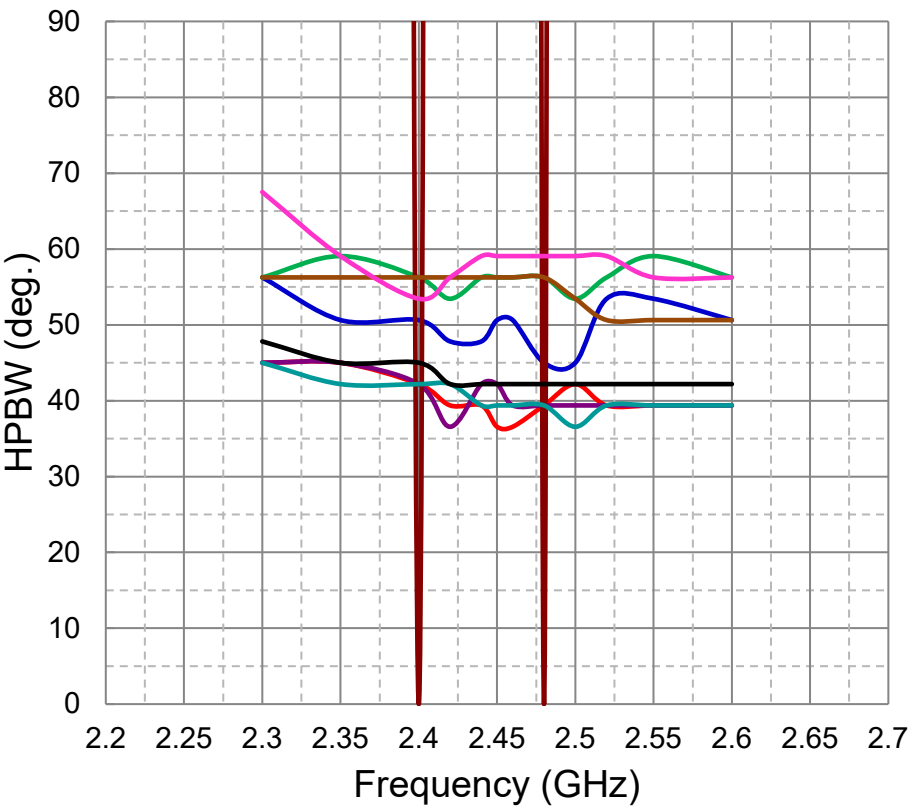


| 2.4GHz | Max     | Mean    | Min     |
|--------|---------|---------|---------|
| Beam 1 | 3.4 dBi | 3.0 dBi | 2.5 dBi |
| Beam 2 | 3.7 dBi | 3.4 dBi | 2.7 dBi |
| Beam 3 | 3.0 dBi | 2.7 dBi | 2.3 dBi |
| Beam 4 | 3.6 dBi | 3.3 dBi | 2.9 dBi |
| Beam 5 | 3.7 dBi | 3.3 dBi | 2.7 dBi |
| Beam 6 | 4.2 dBi | 3.8 dBi | 3.4 dBi |
| Beam 7 | 2.7 dBi | 2.4 dBi | 2.0 dBi |
| Beam 8 | 3.4 dBi | 3.1 dBi | 2.5 dBi |
| Beam 9 | 3.0 dBi | 2.6 dBi | 2.2 dBi |

Beam1 Beam2 Beam3 Beam4 Beam5  
 Beam6 Beam7 Beam8 Beam9

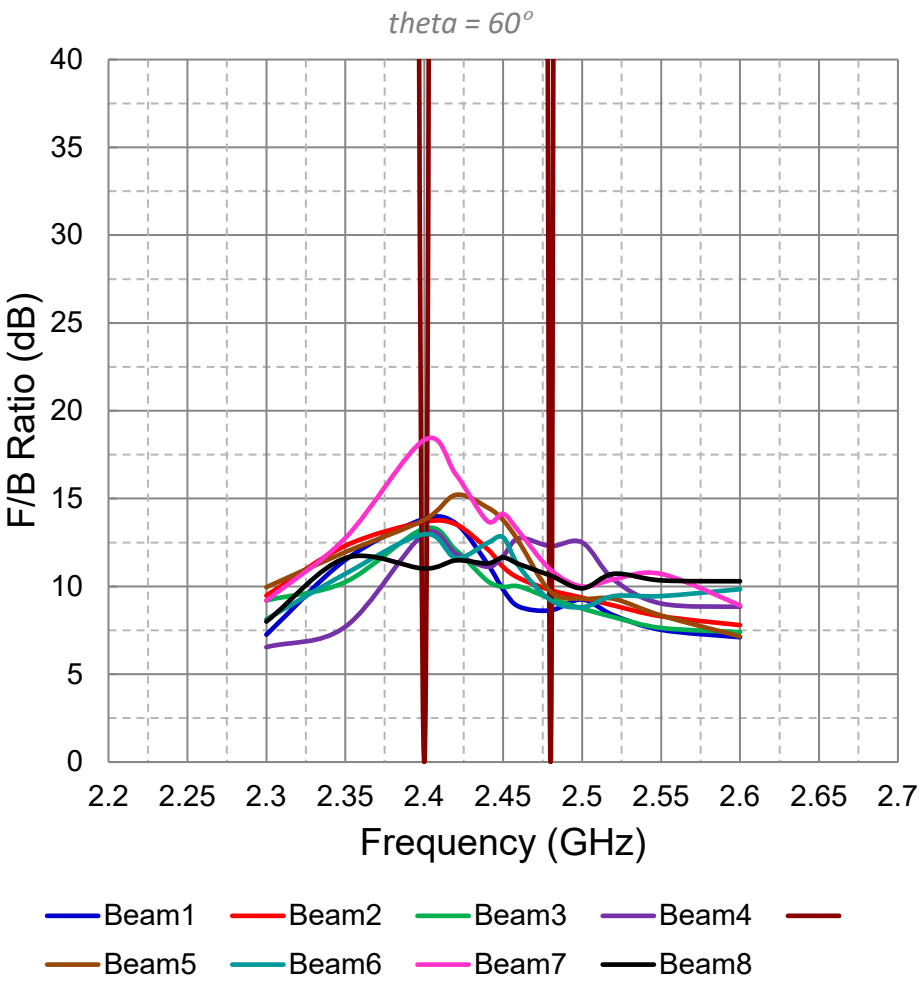
# 3dB Beam Width Directional Beam

$\theta = 60^\circ$



| 2.4GHz  | Max | Mean | Min |
|---------|-----|------|-----|
| Beam 1  | 51  | 49   | 45  |
| Beam 2  | 42  | 39   | 37  |
| Beam 3  | 56  | 56   | 53  |
| Beam 4  | 42  | 40   | 37  |
| Beam 5  | 56  | 56   | 56  |
| Beam 6  | 42  | 40   | 39  |
| Beam 7  | 59  | 58   | 53  |
| Beam 8  | 45  | 43   | 42  |
| Summary | 59  | 48   | 37  |

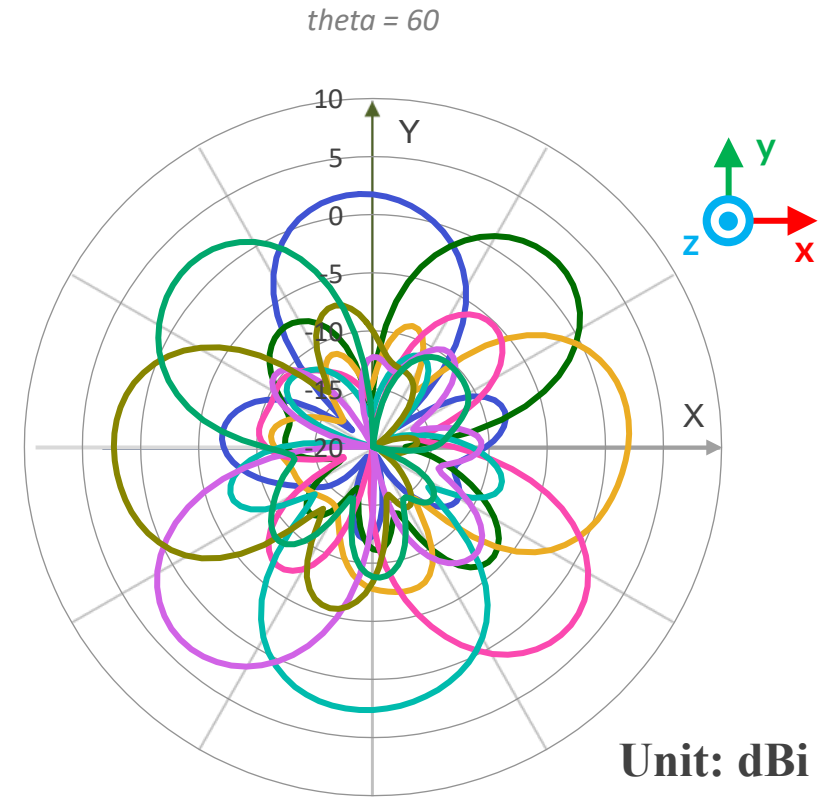
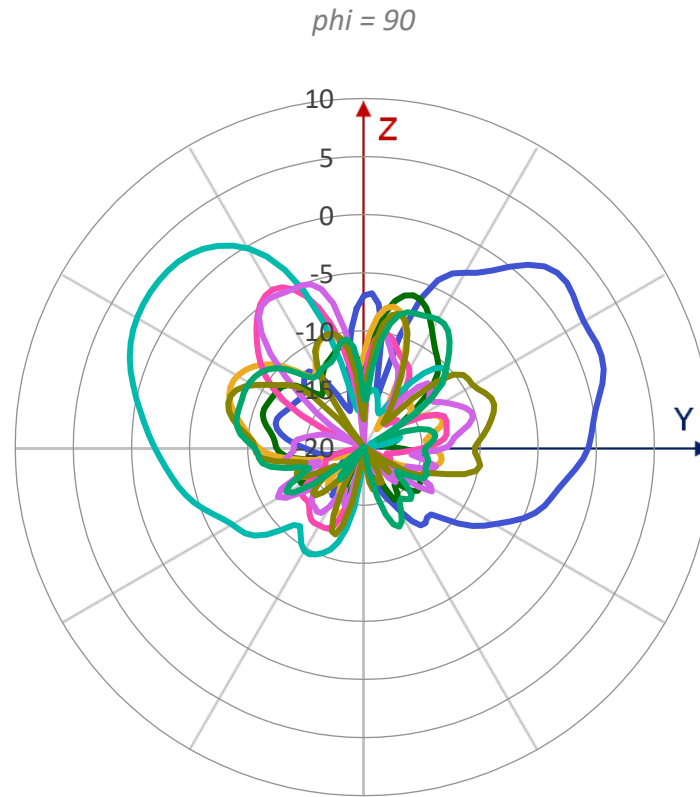
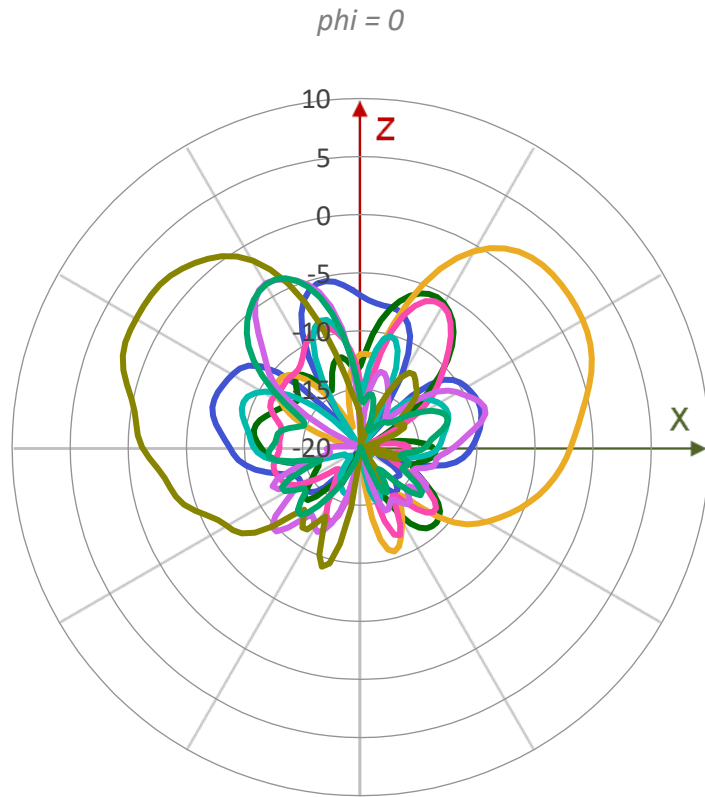
# Front to Back Ratio Directional Beam



| 2.4GHz  | Max  | Mean | Min  |
|---------|------|------|------|
| Beam 1  | 13.9 | 11.0 | 8.6  |
| Beam 2  | 13.7 | 11.8 | 9.8  |
| Beam 3  | 13.3 | 10.8 | 9.3  |
| Beam 4  | 13.0 | 12.1 | 11.1 |
| Beam 5  | 15.2 | 13.3 | 9.7  |
| Beam 6  | 13.0 | 11.7 | 9.2  |
| Beam 7  | 18.3 | 14.4 | 11.0 |
| Beam 8  | 11.6 | 11.2 | 10.6 |
| Summary | 18   | 12   | 9    |

# Realized Gain Pattern

## Directional Beam 1-8 @2400MHz for $G_{\text{total}}$



Unit: dBi

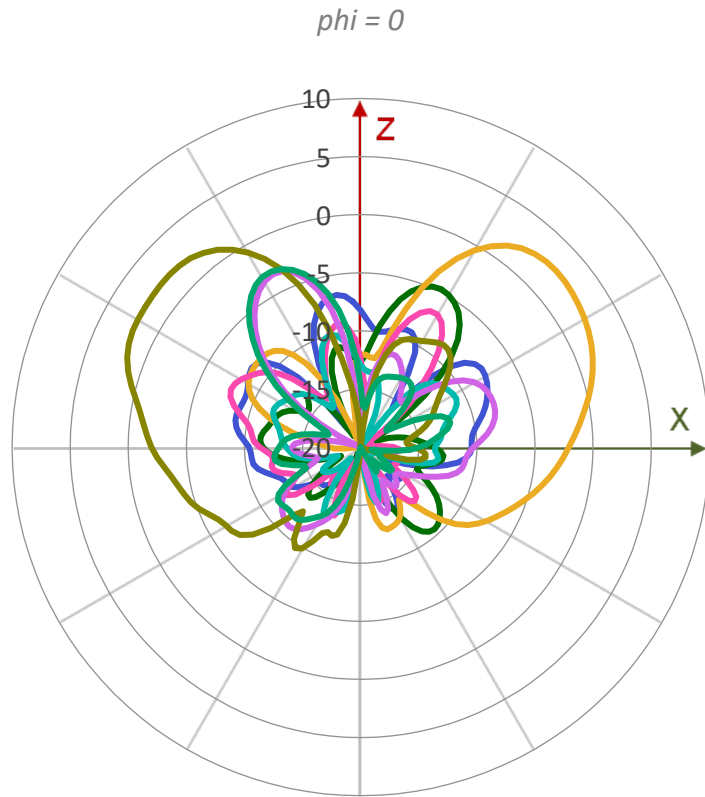
— Beam1 — Beam2 — Beam3 — Beam4  
— Beam5 — Beam6 — Beam7 — Beam8

— Beam1 — Beam2 — Beam3 — Beam4  
— Beam5 — Beam6 — Beam7 — Beam8

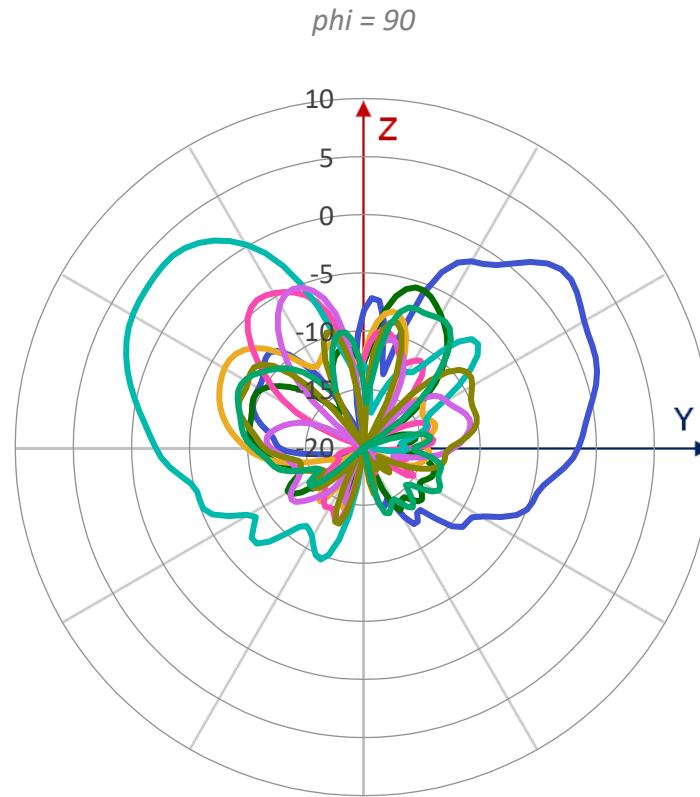
— Beam1 — Beam2 — Beam3 — Beam4  
— Beam5 — Beam6 — Beam7 — Beam8

# Realized Gain Pattern

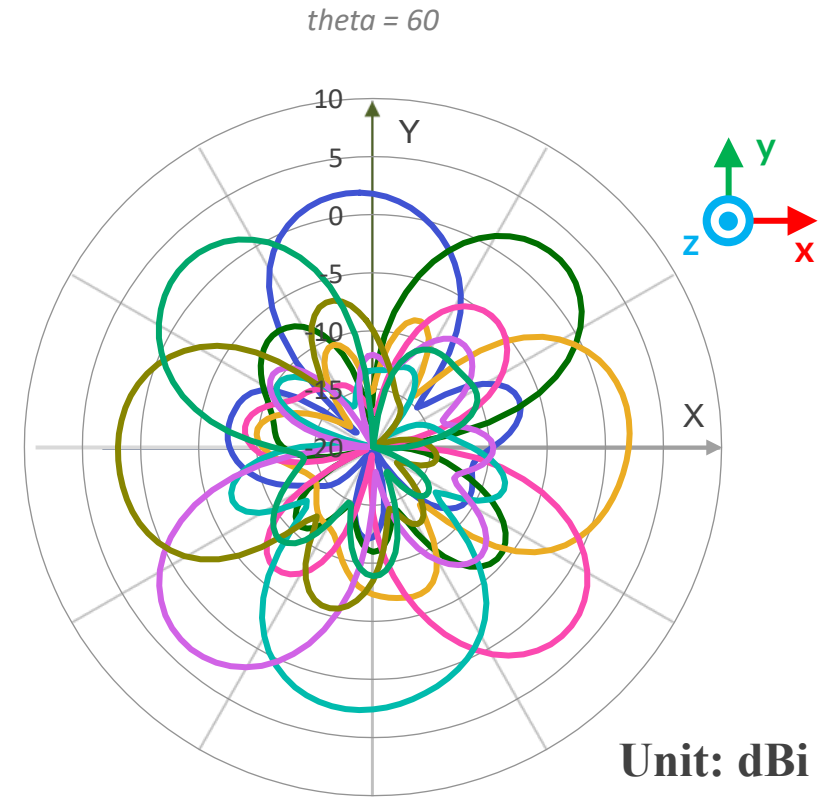
## Directional Beam 1-8 @2440MHz for $G_{\text{total}}$



— Beam1 — Beam2 — Beam3 — Beam4  
— Beam5 — Beam6 — Beam7 — Beam8



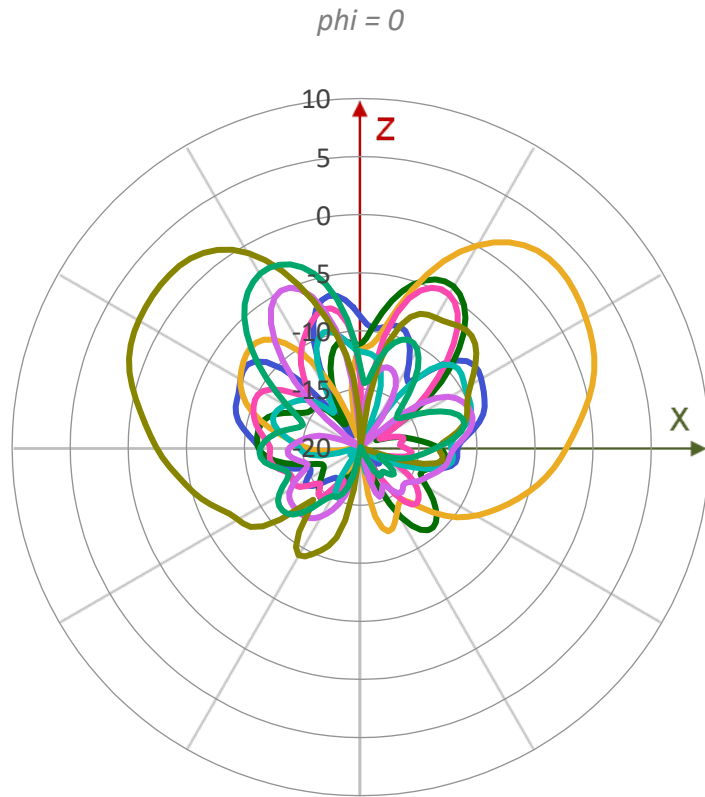
— Beam1 — Beam2 — Beam3 — Beam4  
— Beam5 — Beam6 — Beam7 — Beam8



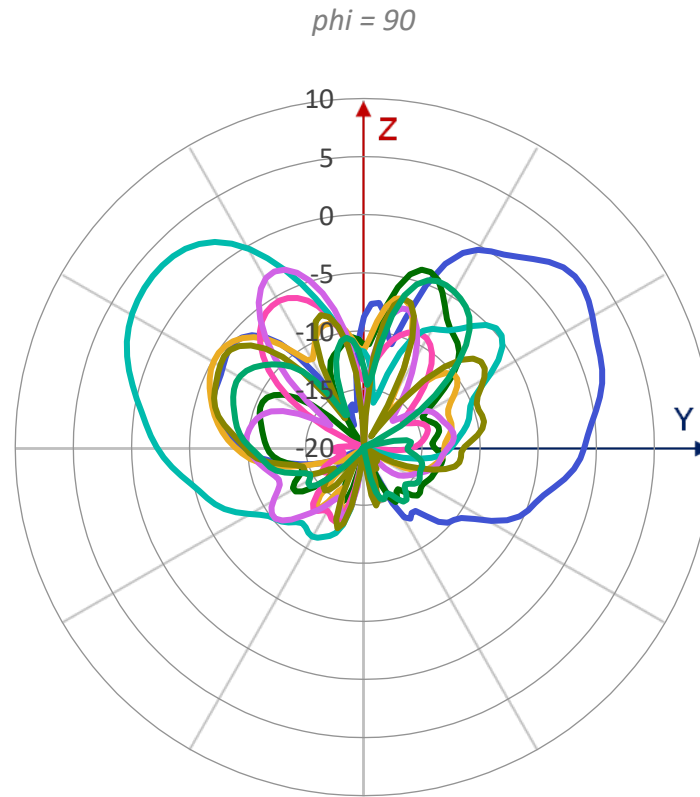
— Beam1 — Beam2 — Beam3 — Beam4  
— Beam5 — Beam6 — Beam7 — Beam8

# Realized Gain Pattern

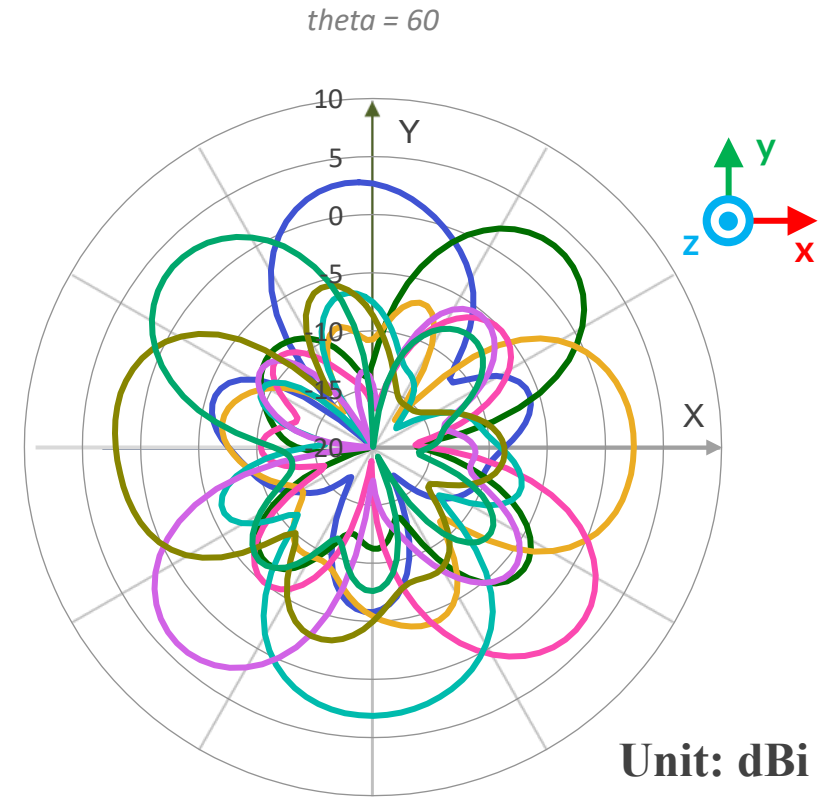
## Directional Beam 1-8 @2480MHz for $G_{\text{total}}$



— Beam1 — Beam2 — Beam3 — Beam4  
— Beam5 — Beam6 — Beam7 — Beam8



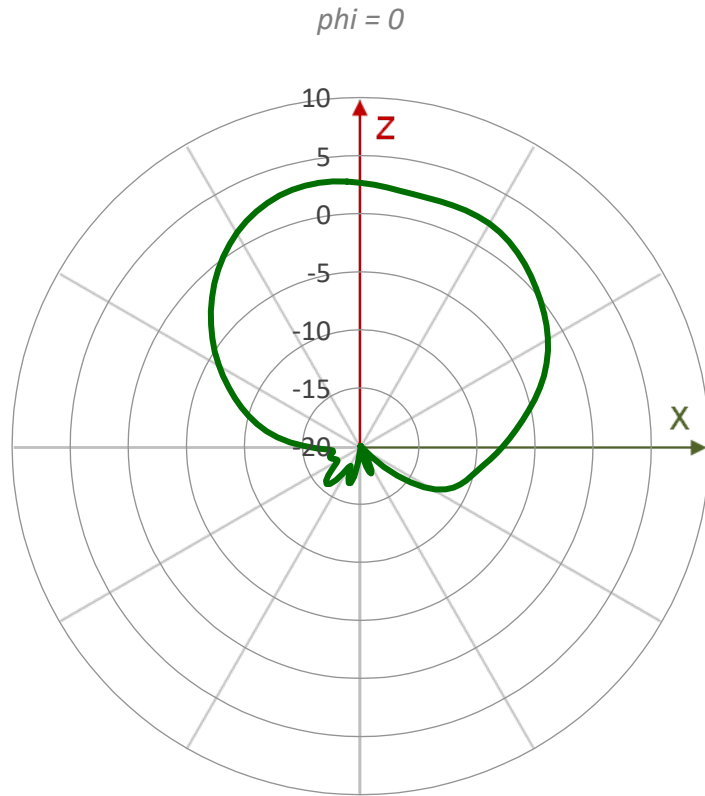
— Beam1 — Beam2 — Beam3 — Beam4  
— Beam5 — Beam6 — Beam7 — Beam8



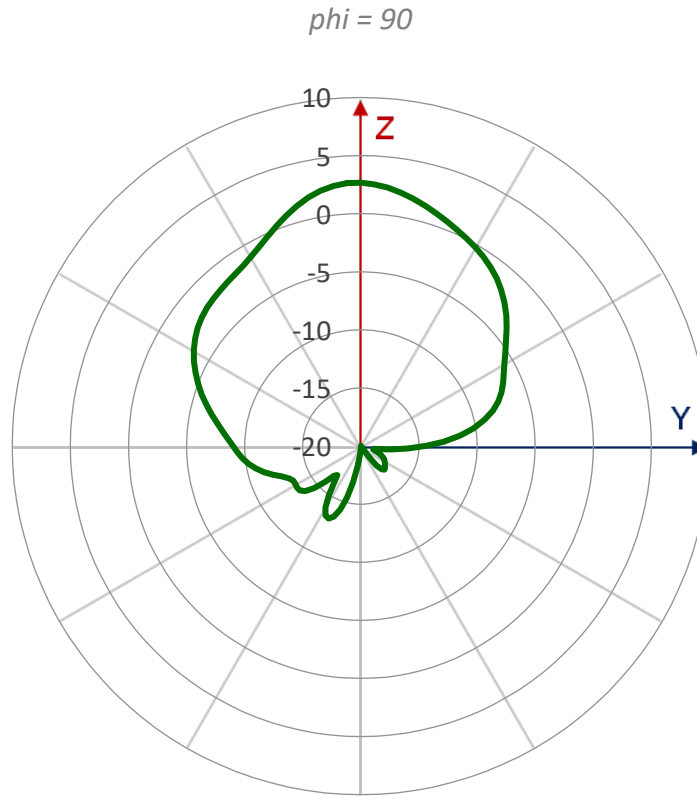
— Beam1 — Beam2 — Beam3 — Beam4  
— Beam5 — Beam6 — Beam7 — Beam8

# Realized Gain Pattern

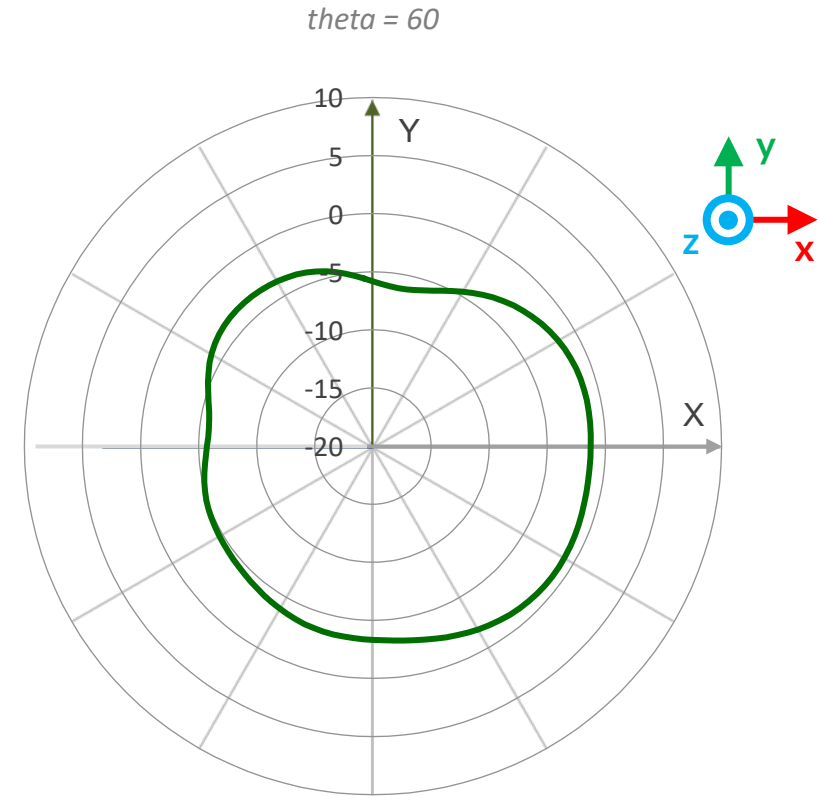
Directional Beam 9 @2400MHz for Gtotal



— Beam9



— Beam9

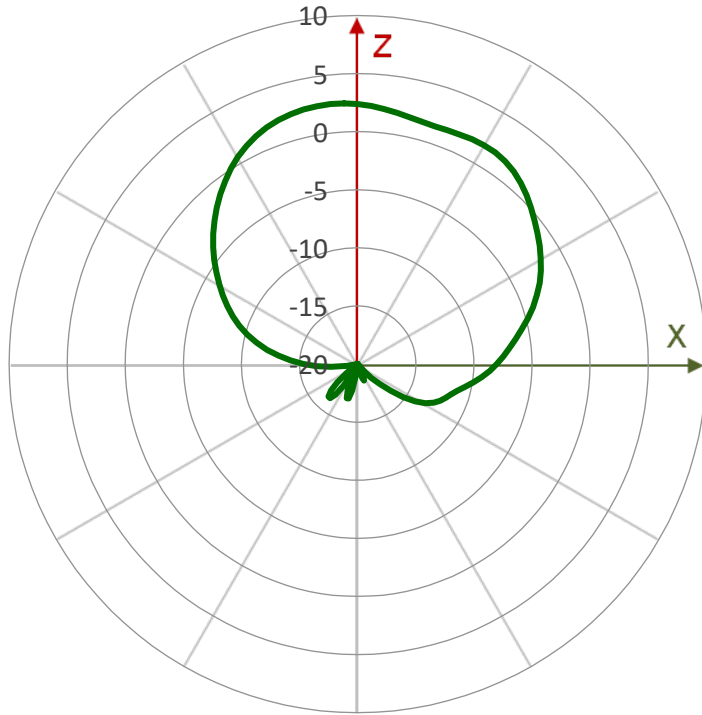


— Beam9

# Realized Gain Pattern

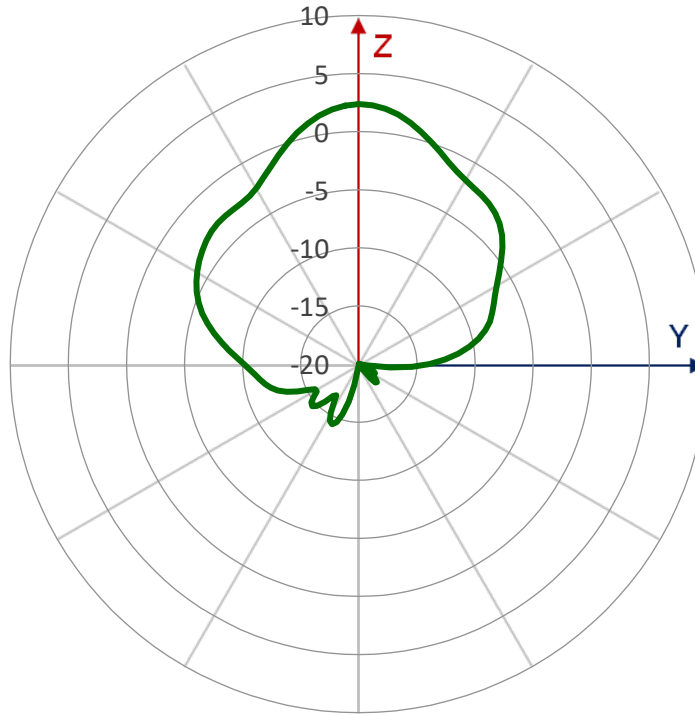
Directional Beam 9 @2440MHz for Gtotal

$\phi = 0$



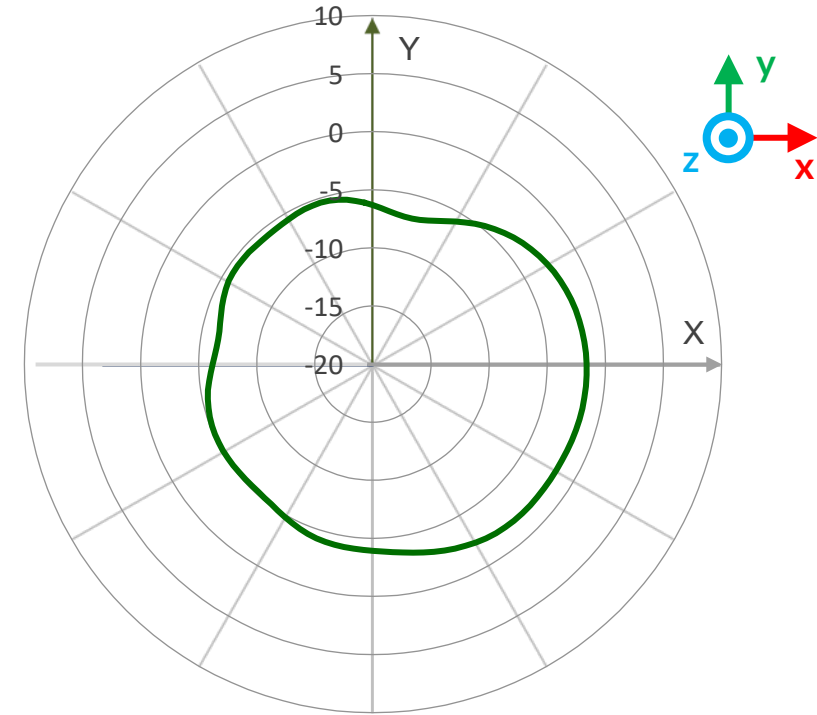
— Beam9

$\phi = 90$



— Beam9

$\theta = 60$

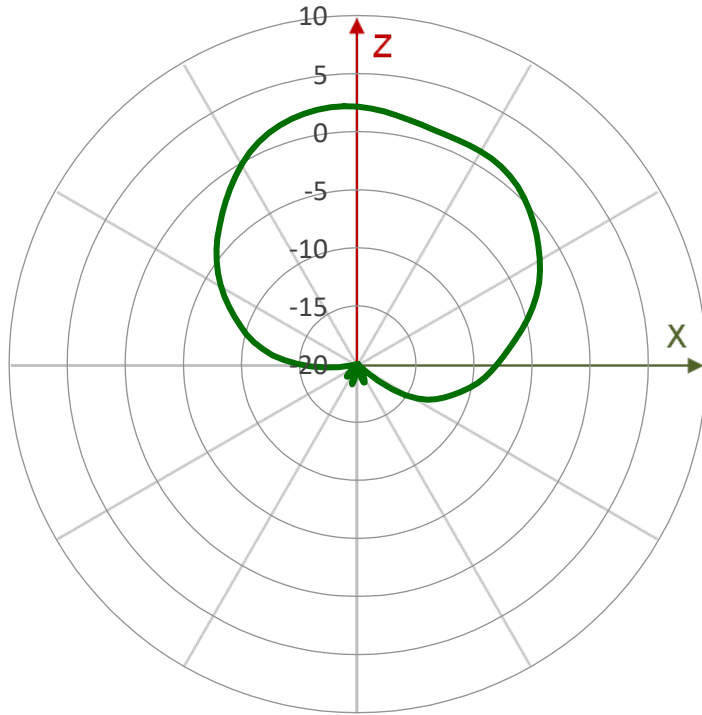


— Beam9

# Realized Gain Pattern

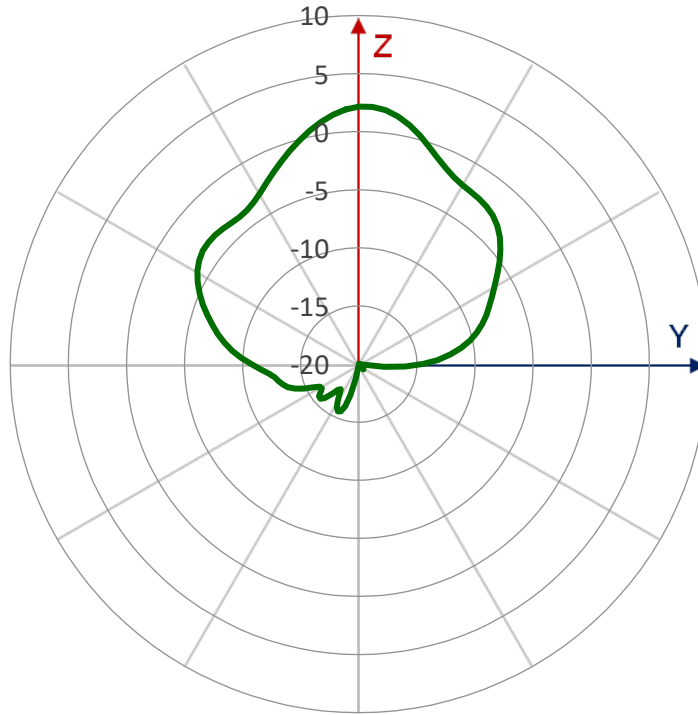
Directional Beam 9 @2480MHz for Gtotal

$\phi = 0$



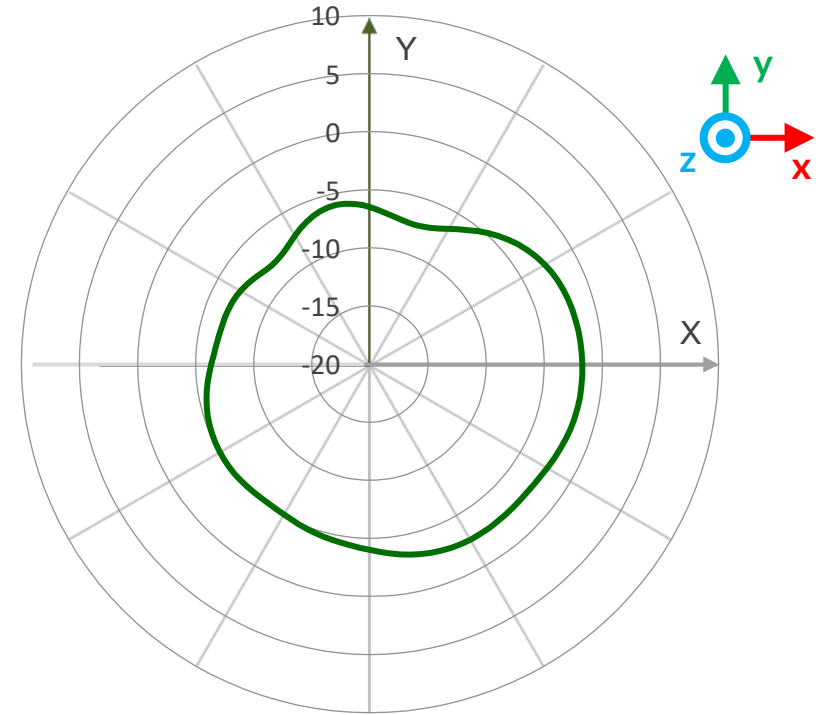
— Beam9

$\phi = 90$



— Beam9

$\theta = 60$

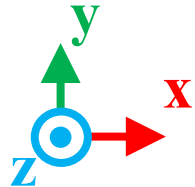


— Beam9

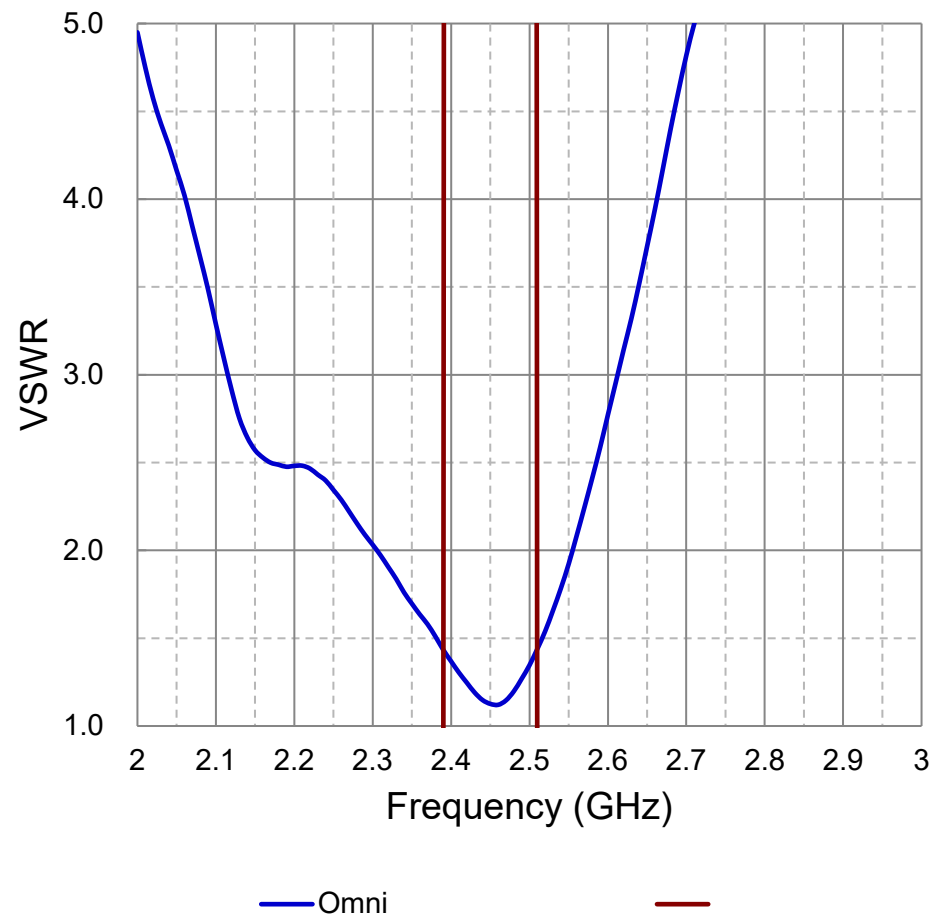
# BLE Array – Omni Beam



- **Maximum VSWR**
  - 1.4:1 on 2.4GHz
- **Efficiency**
  - ~19% on 2.4GHz
- **Peak Gain**
  - -0.4dBi on 2.4GHz

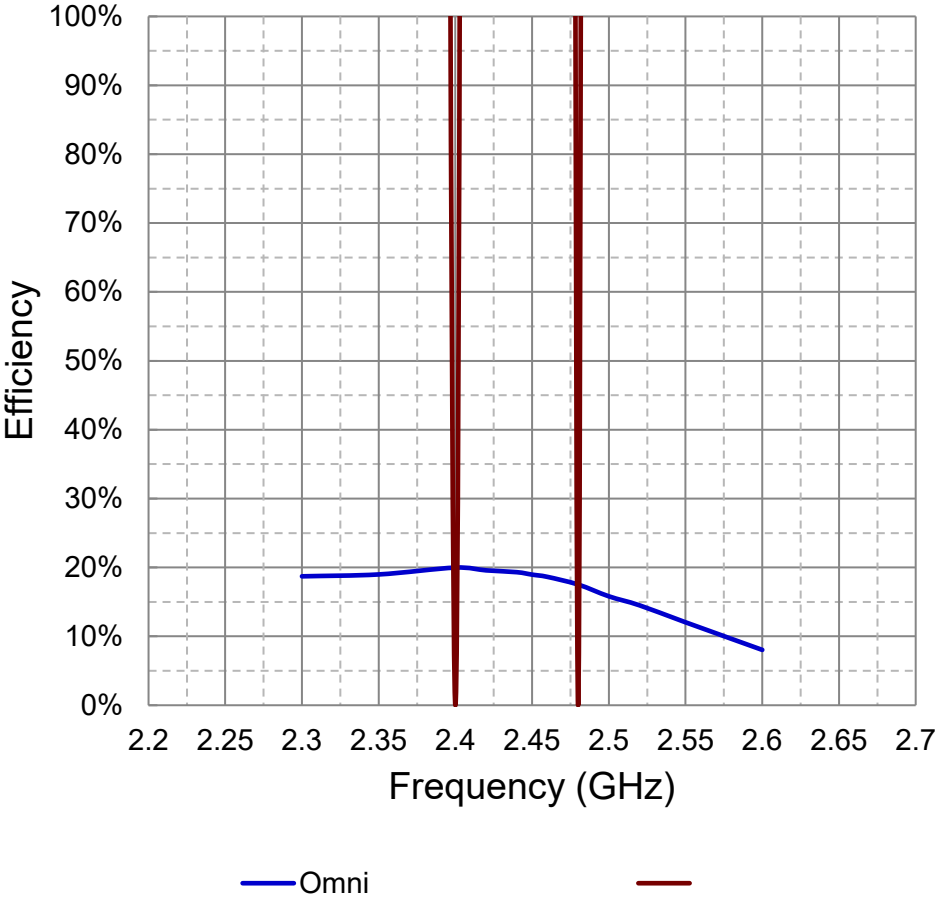


# VSWR Omni Beam



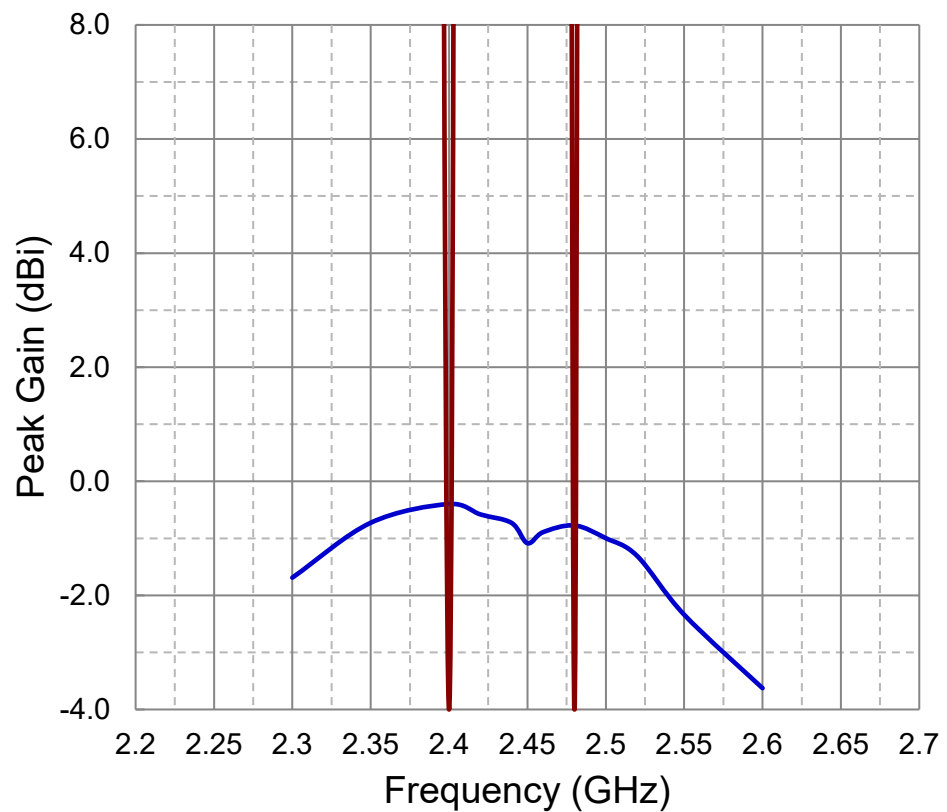
| 2.4GHz | Max | Mean | Min |
|--------|-----|------|-----|
| Omni   | 1.4 | 1.2  | 1.1 |

# Efficiency Omni Beam



| 2.4GHz | Max  | Mean | Min  |
|--------|------|------|------|
| Omni   | 20 % | 19 % | 18 % |

# Peak Gain **Omni Beam**



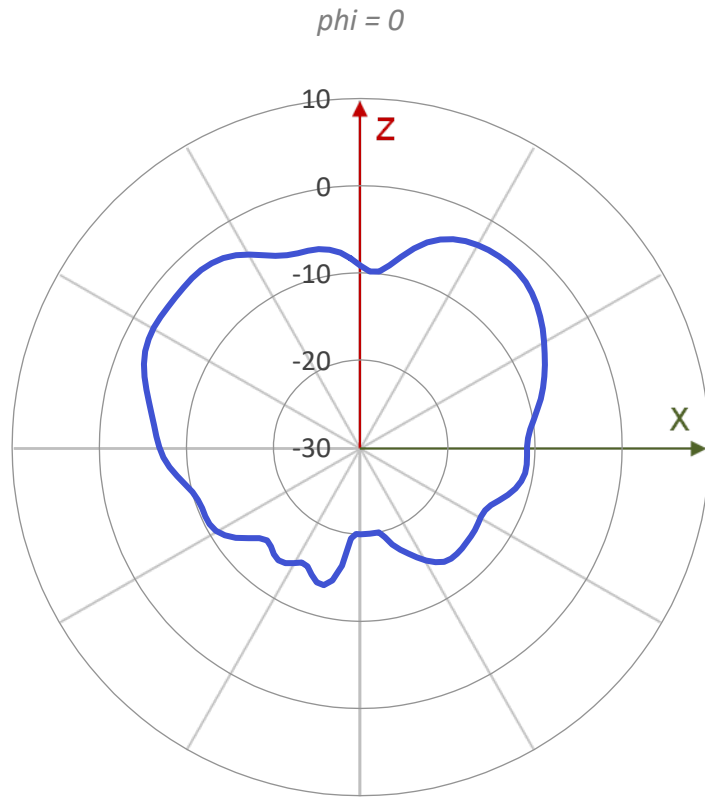
— Omni

—

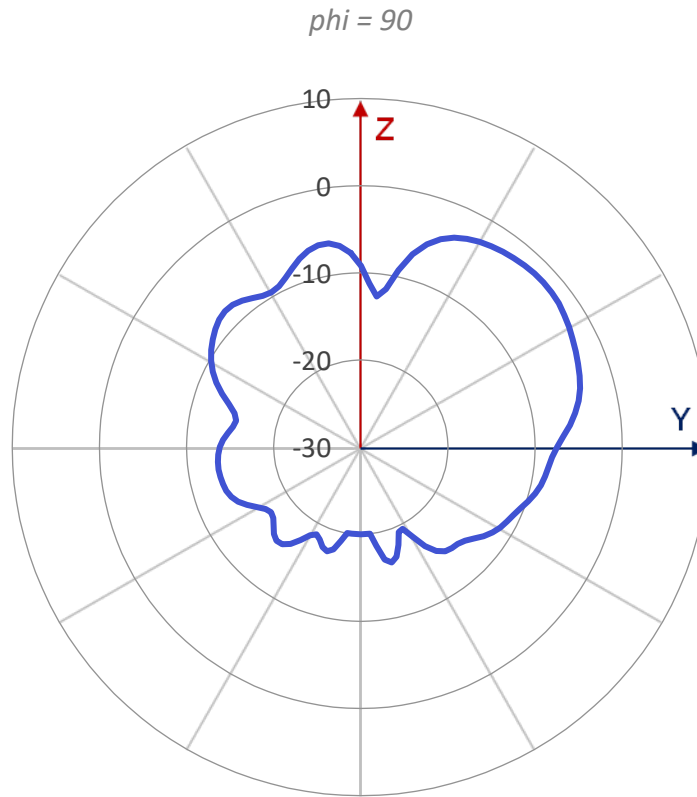
| 2.4GHz | Max      | Mean     | Min      |
|--------|----------|----------|----------|
| Sub1   | -0.4 dBi | -0.7 dBi | -1.1 dBi |

# Realized Gain Pattern

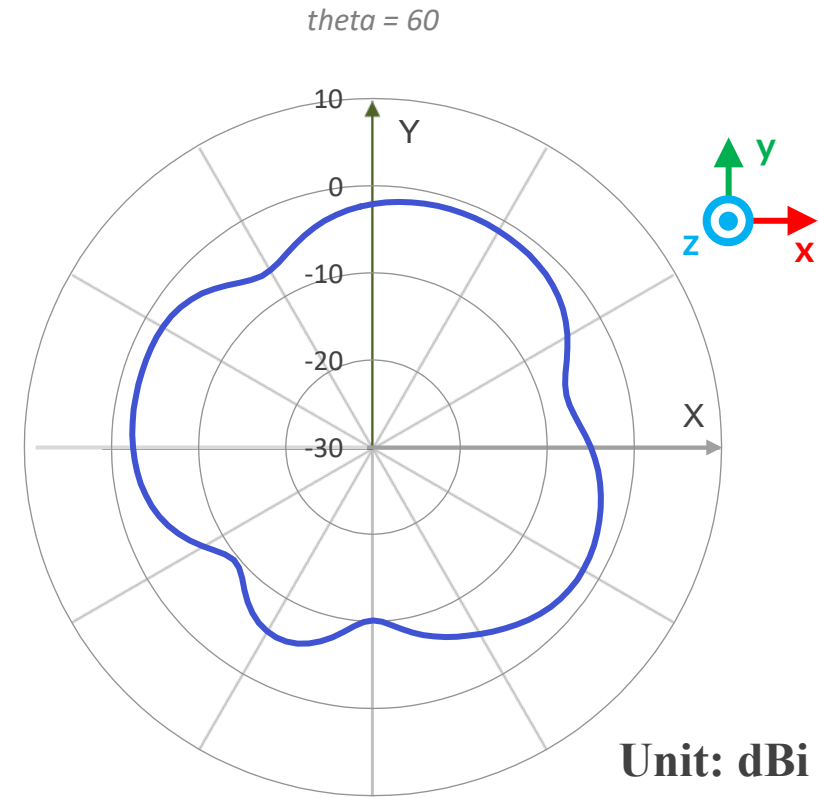
## Omni Beam @2440MHz for $G_{\text{total}}$



— Omni



— Omni



— Omni

