



**Sensolus**  
**HATI**  
**CU23006-1**

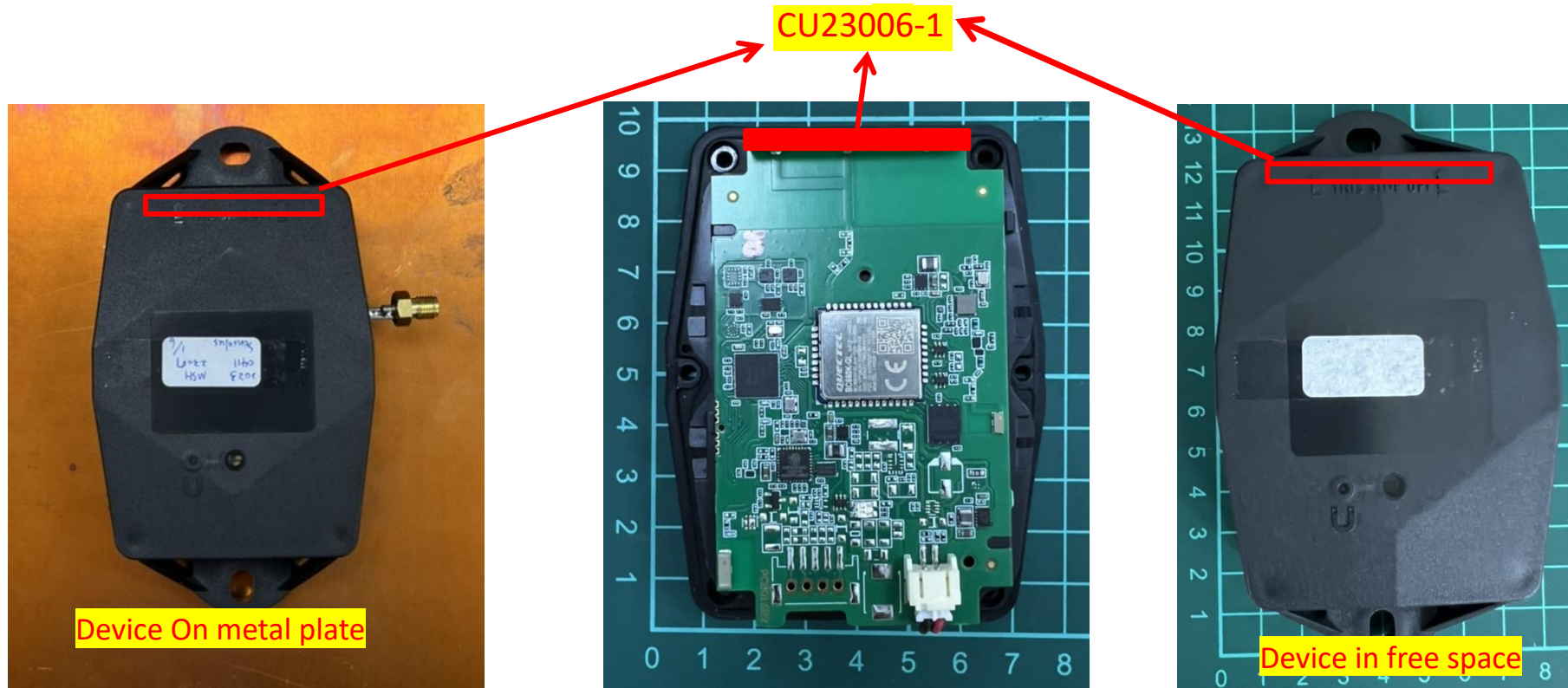
Author: Kobe Chiang

Date: 20 NOV 2023

Project: CU23006-02

# Introduction

- Sensolus supplied the device to find the optimal matching circuit for LTE application.
- The device was measured in an Anechoic chamber to characterise the antenna within the device.



# Equipment used

## Return loss/Isolation



Agilent E5071C (9KHz-8.5GHz) ENA

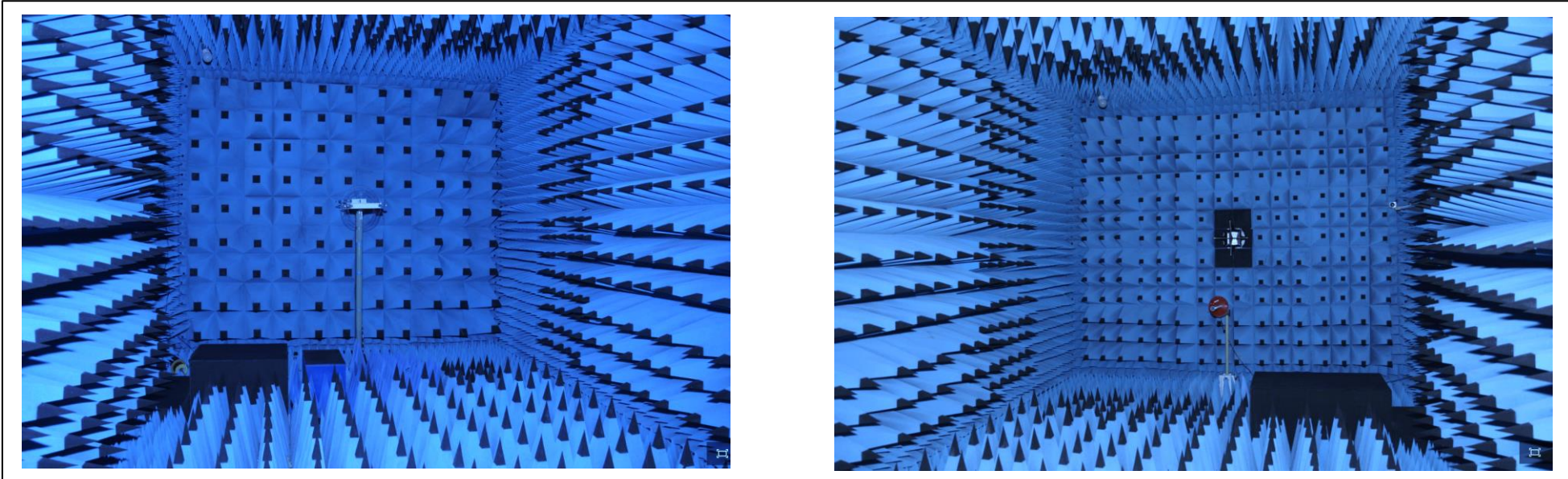
## Passive Efficiency



Chamber equipment Rig

# Equipment used

## Anechoic chamber 700MHz – 6000MHz



All tests using this arrangement were performed in free space. The return loss at the input of the matching circuit was measured using an Agilent ENA E5071C RF Network Analyser.

# Results Summary

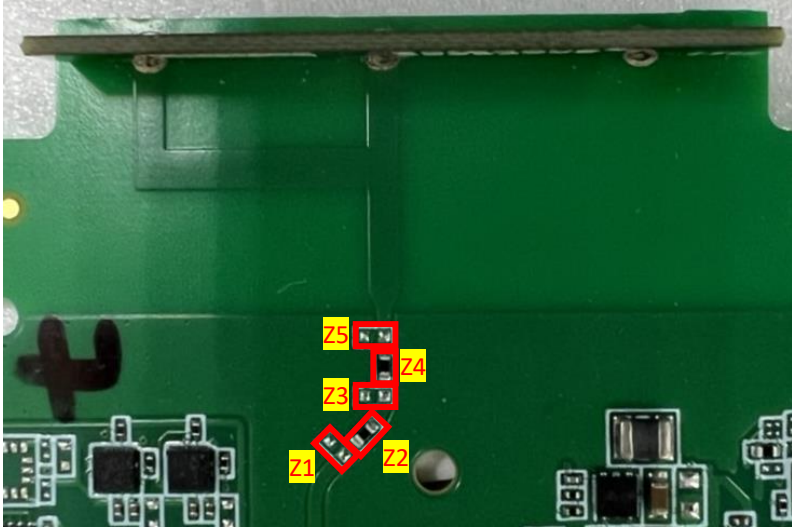
| <b><i>CU23006-1<br/>(in free space)</i></b> | <b><i>698 – 960 MHz</i></b> | <b><i>1710 – 2200 MHz</i></b> | <b><i>2300 – 2690 MHz</i></b> |
|---------------------------------------------|-----------------------------|-------------------------------|-------------------------------|
| Return Loss                                 | <-2.7 dB                    | <-6.5 dB                      | <-4.5 dB                      |
| Efficiency (Min)                            | 17.1%                       | 37.1%                         | 37.9%                         |
| Efficiency (Avg)                            | 38.0%                       | 58.9%                         | 47.4%                         |
| Gain (Peak)                                 | 1.5dBi                      | 3.7dBi                        | 2.9dBi                        |
| Gain (Avg)                                  | -4.1dB                      | -2.3dB                        | -3.2dB                        |

| <b><i>CU23006-1<br/>(on metal plate)</i></b> | <b><i>698 – 960 MHz</i></b> | <b><i>1710 – 2200 MHz</i></b> | <b><i>2300 – 2690 MHz</i></b> |
|----------------------------------------------|-----------------------------|-------------------------------|-------------------------------|
| Return Loss                                  | <-2.8 dB                    | <-4.6 dB                      | <-4.6 dB                      |
| Efficiency (Min)                             | 9.1%                        | 35.7%                         | 39.7%                         |
| Efficiency (Avg)                             | 13.4%                       | 52.2%                         | 45%                           |
| Gain (Peak)                                  | -1.8dBi                     | 6.6dBi                        | 5.6dBi                        |
| Gain (Avg)                                   | -8.7dB                      | -2.8dB                        | -3.4dB                        |

# Antenova Recommended Matching Circuit

- The recommended matching circuit was found for the current device setup.

Circuit diagram

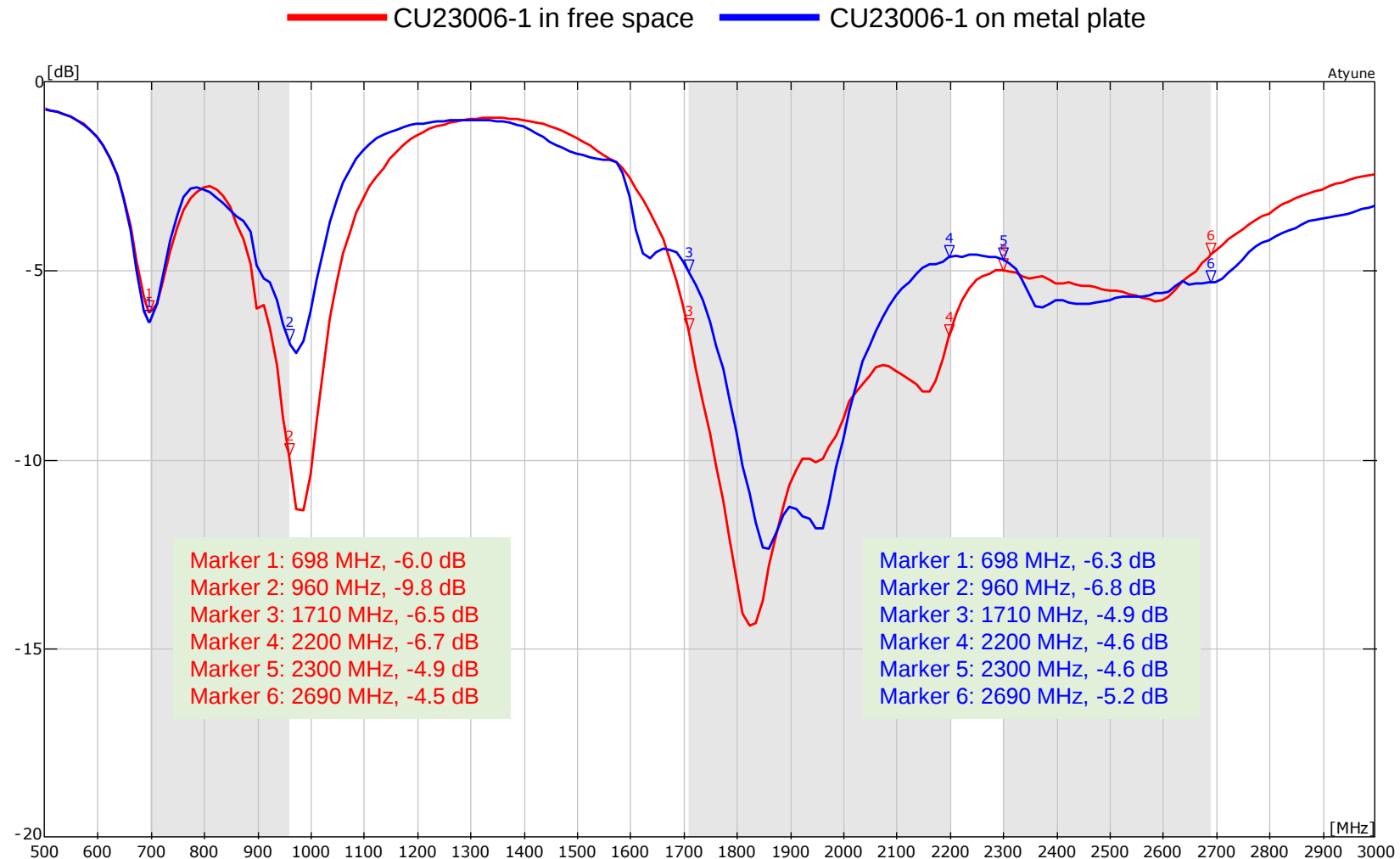


BOM (Bill of Materials)

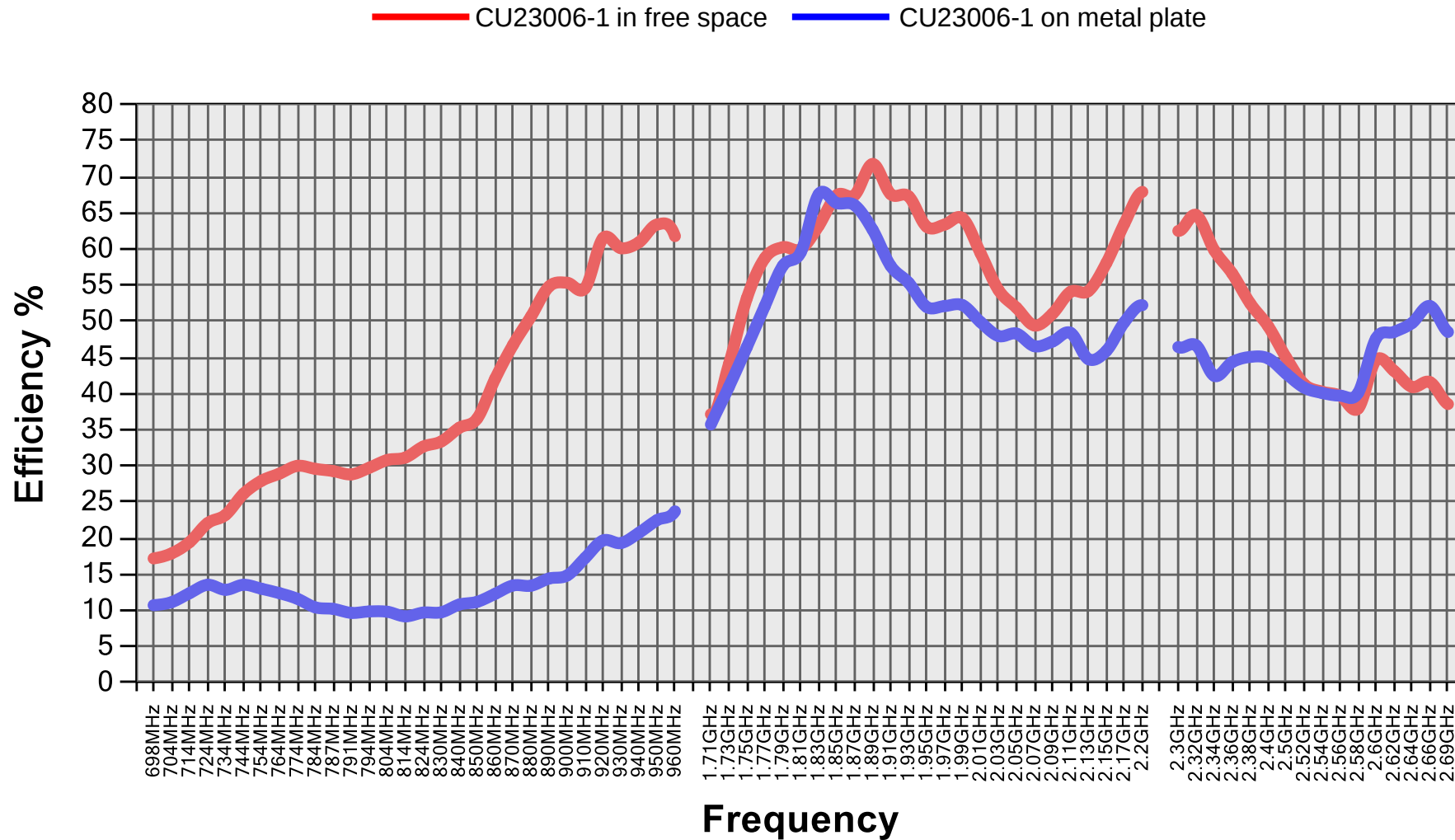
| CU23006-1  |           |        |              |              |
|------------|-----------|--------|--------------|--------------|
| Designator | Type      | Value  | Manufacturer | Series       |
| Z1         | Inductor  | 47 nH  | Murata       | LQG15 series |
| Z2         | Resistor  | 0 ohm  | Non-Specific | Non-Specific |
| Z3         | Inductor  | 7.5 nH | Murata       | LQG15 series |
| Z4         | Capacitor | 3.6 pF | Murata       | GJM15 series |
| Z5         | Inductor  | 6.2 nH | Murata       | LQG15 series |

*The recommended matching circuit is valid only for the hardware configuration provided. Any changes to the PCB layout, hardware or relative position of the antenna, including microphones, speakers, batteries, cases, etc, may modify the antenna impedance and it would require a different matching circuit.*

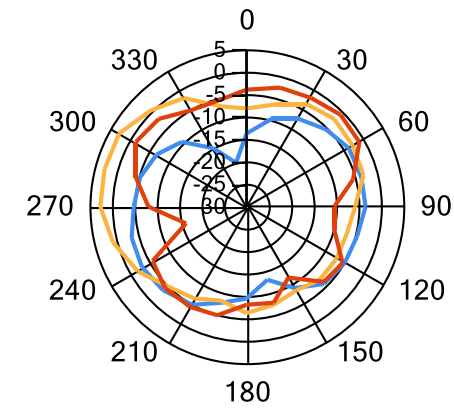
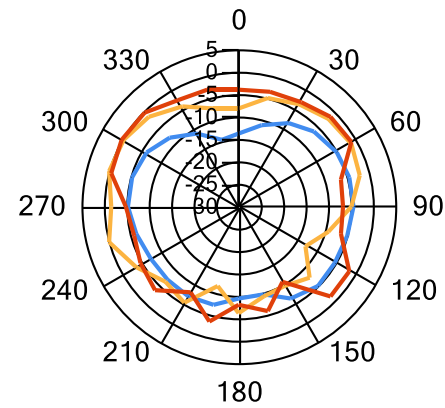
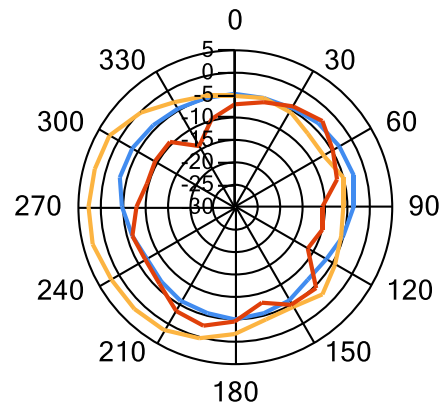
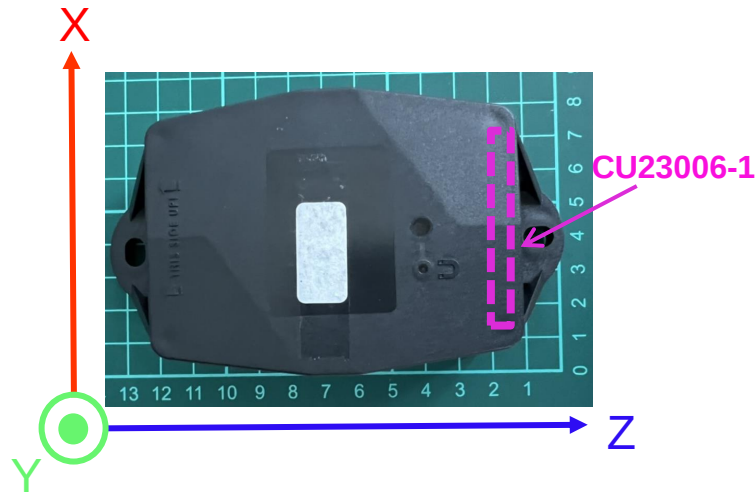
# S-parameter



# Antenna Efficiency

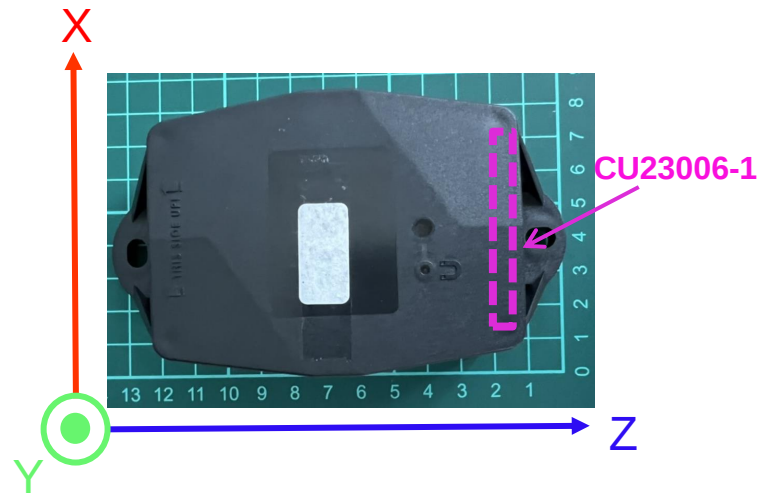


# Antenna Radiation Pattern-2D-in free space

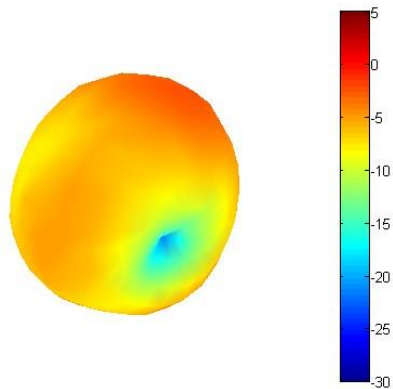


— 824MHz — 1.95GHz — 2.5GHz

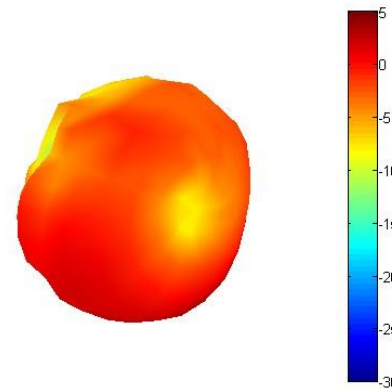
# Antenna Radiation Pattern-3D-in free space



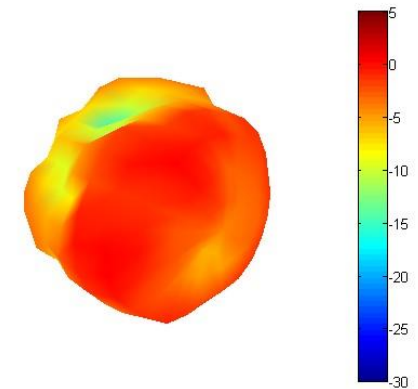
Patterns @ 824MHz



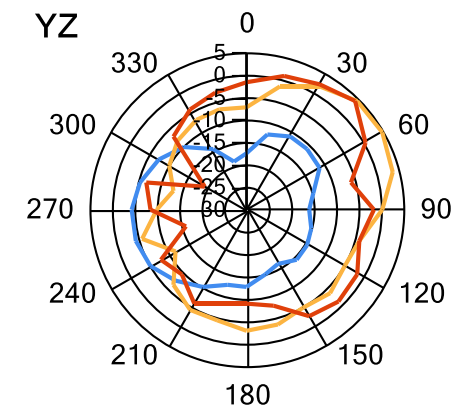
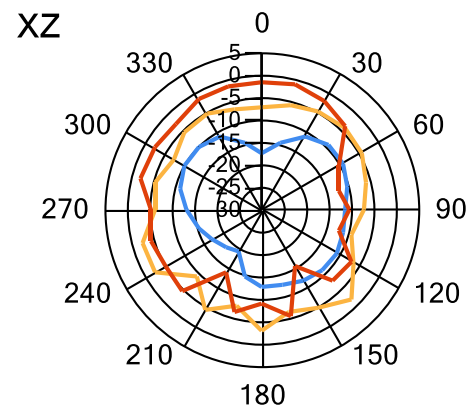
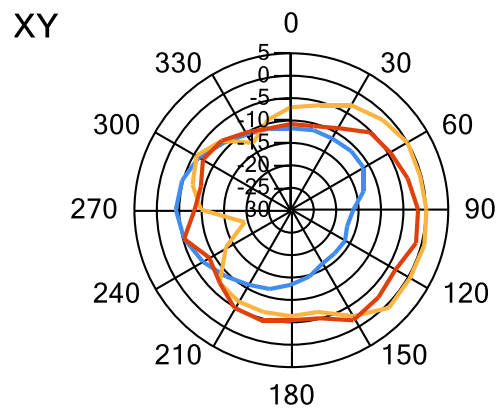
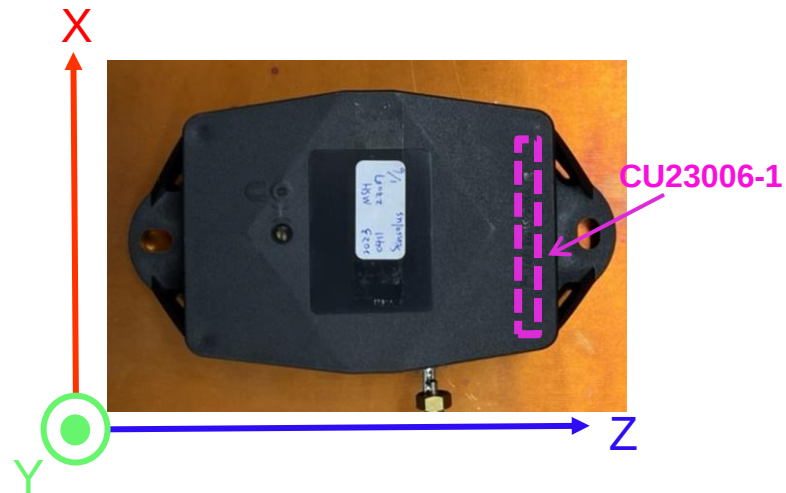
Patterns @ 1950MHz



Patterns @ 2500MHz

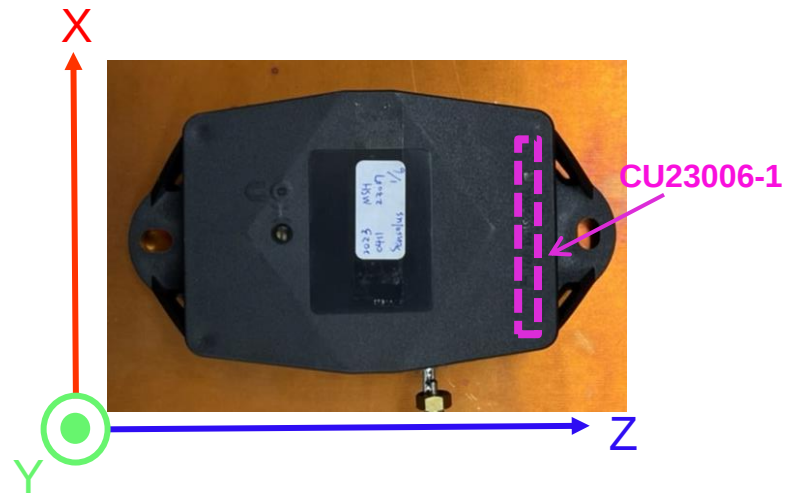


# Antenna Radiation Pattern-2D-on metal plate

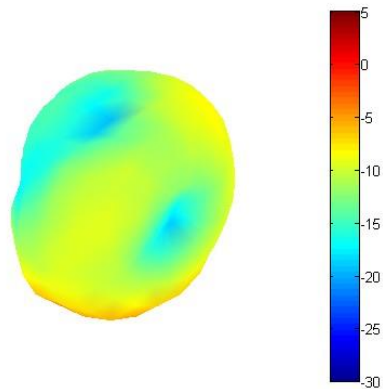


— 824MHz — 1.95GHz — 2.5GHz

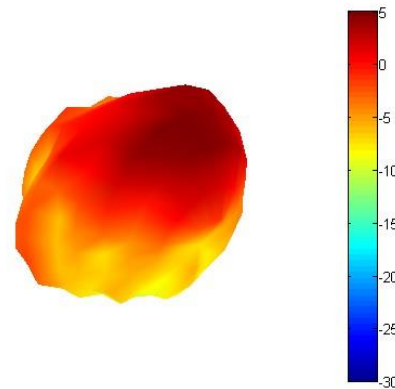
# Antenna Radiation Pattern-3D-on metal plate



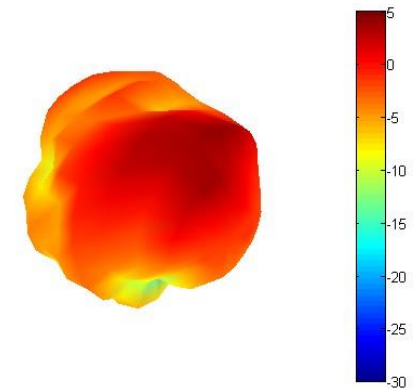
Patterns @ 824MHz



Patterns @ 1950MHz



Patterns @ 2500MHz



# Conclusions

- The antenna performance is optimal for the device setup.
- Antenna efficiency, gain, radiation were provided in this report.
- Given the environment, the average efficiency are:

| CU23006-1      | 698 – 960 MHz        | 1710 – 2200 MHz      | 2300 – 2690 MHz      |
|----------------|----------------------|----------------------|----------------------|
| In free space  | Avg. efficiency: 38% | Avg. efficiency: 58% | Avg. efficiency: 47% |
| On metal plate | Avg. efficiency: 13% | Avg. efficiency: 52% | Avg. efficiency: 45% |

# TRP & Efficiency

The below table shows the relationship between the passive performance Gain and TRP (Total Radiated Power). This does not represent a certainty for the active performance but is to be used as a guide only. A device may still fail certification due to device issues not related to the antenna.

| <i>Efficiency</i> | <i>Antenna Gain<sub>avg</sub></i> | <i>2G 850/900</i> | <i>2G 1800/1900</i> | <i>3G</i> | <i>LTE</i> |
|-------------------|-----------------------------------|-------------------|---------------------|-----------|------------|
| 100%              | 0dB                               | 33dBm             | 30dBm               | 24dBm     | 23dBm      |
| 50%               | -3dB                              | 30dBm             | 27dBm               | 21dBm     | 20dBm      |
| 25%               | -6dB                              | 27dBm             | 23dBm               | 18dBm     | 17dBm      |
| 10%               | -10dB                             | 23dBm             | 20dBm               | 14dBm     | 13dBm      |
| 5%                | -13dB                             | 20dBm             | 17dBm               | 11dBm     | 10dBm      |

*Please note: This is to be used as a guide and may not represent how the antenna and radio system will perform as a unit. It is recommended to measure the Total Radiated Power (TRP) for actual results.*

# Statement on Intellectual Property & Disclaimer



## **Statement on Intellectual Property**

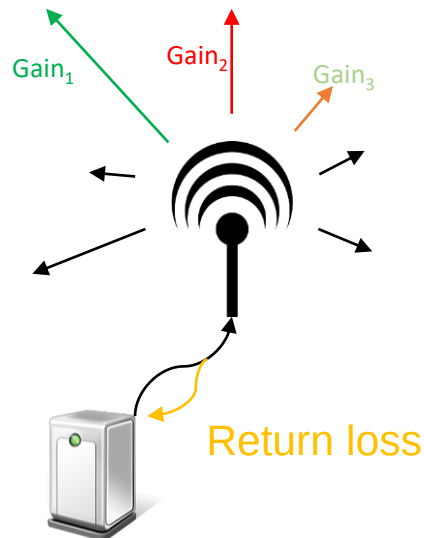
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End of Document

- **Return Loss:** It is the loss of signal power resulting from the reflection caused at a discontinuity in a transmission line.
- **Gain:** It is a figure which combines the antenna's directivity and electrical efficiency, and describes how well the antenna converts input power into radio wave headed in a specified direction and how well the antenna converts radio waves arriving from a specified direction into electrical power.
- **Efficiency:** The ratio of the total power radiated by an antenna to the net power accepted by the antenna from the connected transmitter.
- **Radiation Pattern:** A plot of the gain as a function of direction.



$$\frac{1}{\text{return loss}} \propto \text{Efficiency} \propto \frac{\text{Gain}_1 + \text{Gain}_2 + \text{Gain}_3 + \dots + \text{Gain}_N}{N}$$