Sensolus

HATI

CU23006-1

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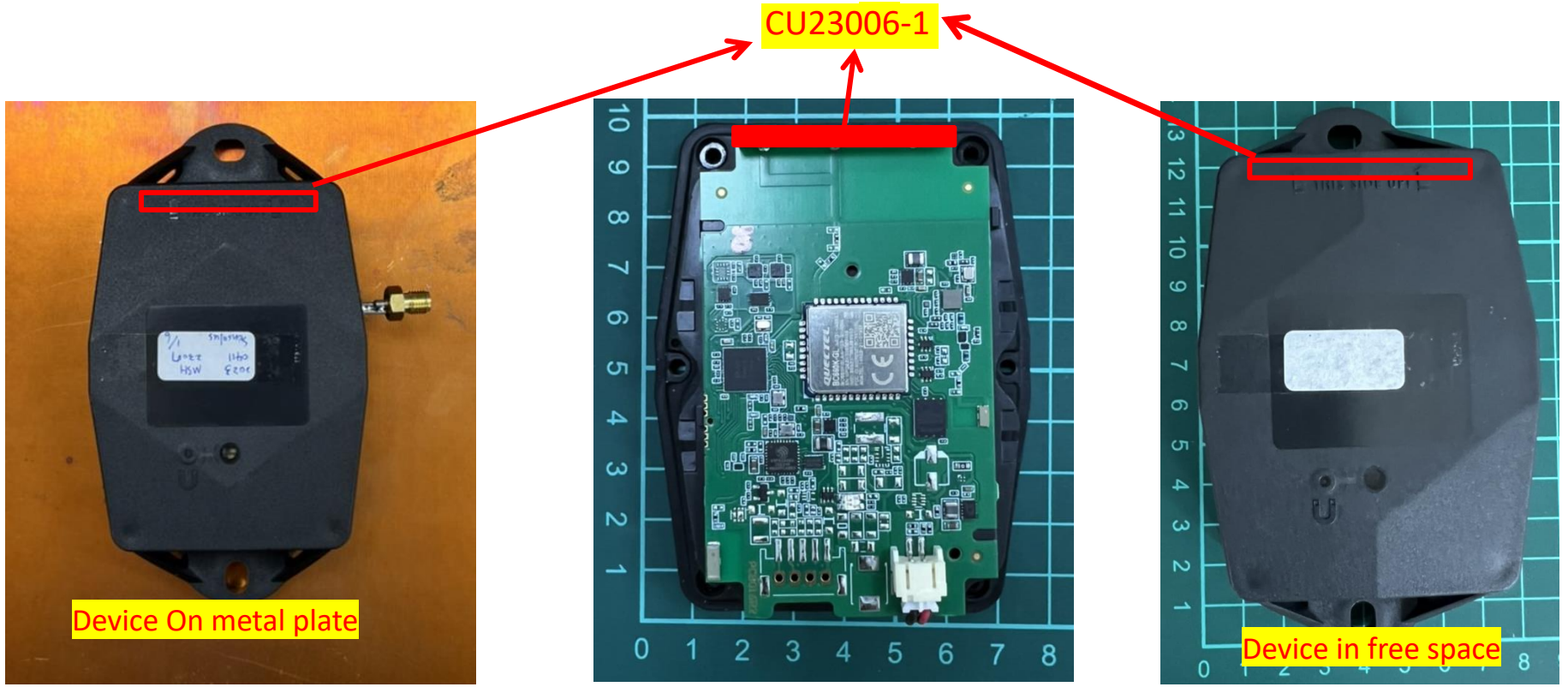
Date:20 NOV 2023

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.



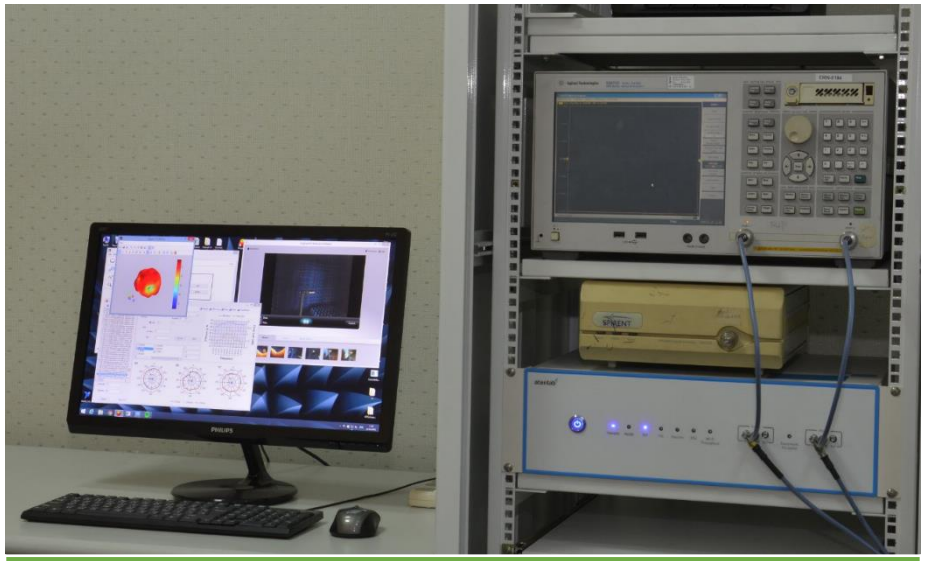
Equipment used

antenova®

Return loss/Isolation

Agilent E5071C (9KHz-8.5GHz) ENA

Passive Efficiency

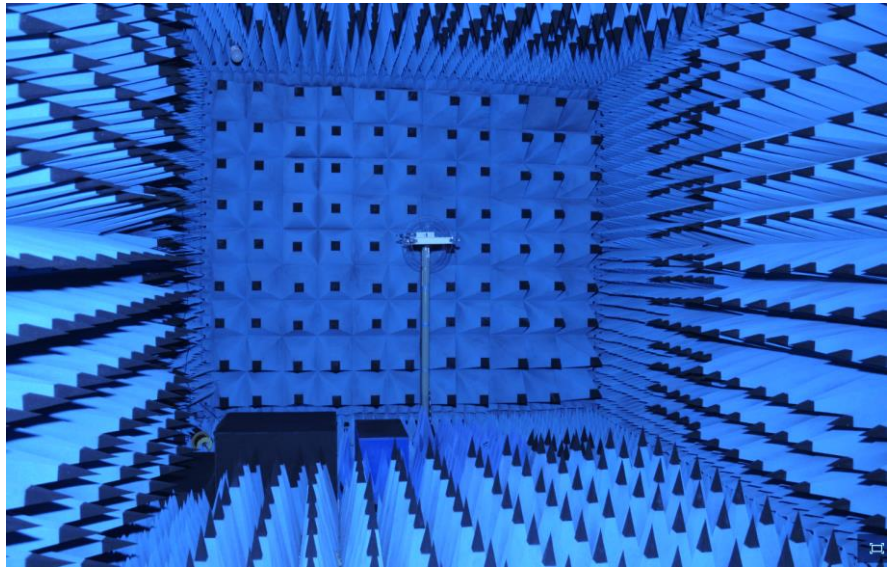


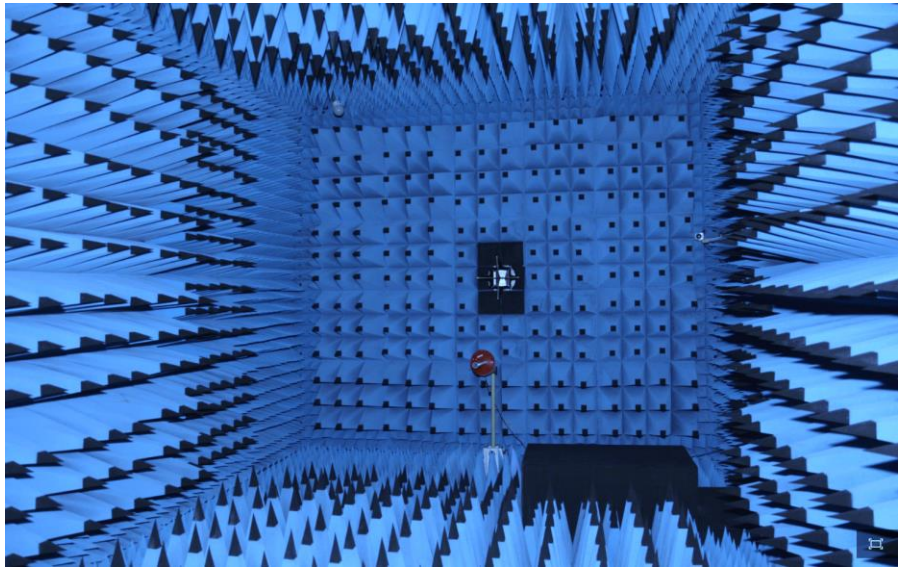
Chamber equipment Rig

Equipment used

antenova®

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

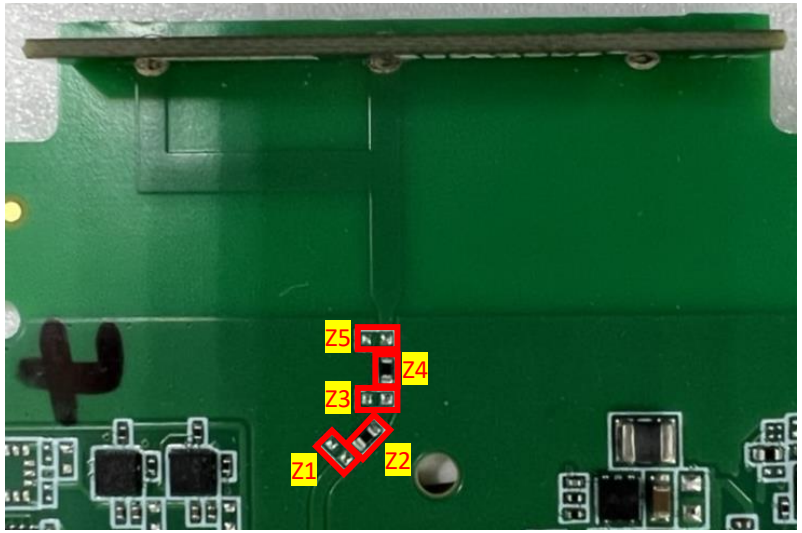
CU23006-1 (in free space)	*698 – 960 MHz*	*1710 – 2200 MHz*	*2300 – 2690 MHz*
Return Loss	<-2.7 dB	<-6.5 dB	<-4.5 dB
Efficiency (Min)	17.1%	37.1%	37.9%
Efficiency (Avg)	38.0%	58.9%	47.4%
Gain (Peak)	1.5dBi	3.7dBi	2.9dBi
Gain (Avg)	-4.1dB	-2.3dB	-3.2dB

CU23006-1 (on metal plate)	*698 – 960 MHz*	*1710 – 2200 MHz*	*2300 – 2690 MHz*
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

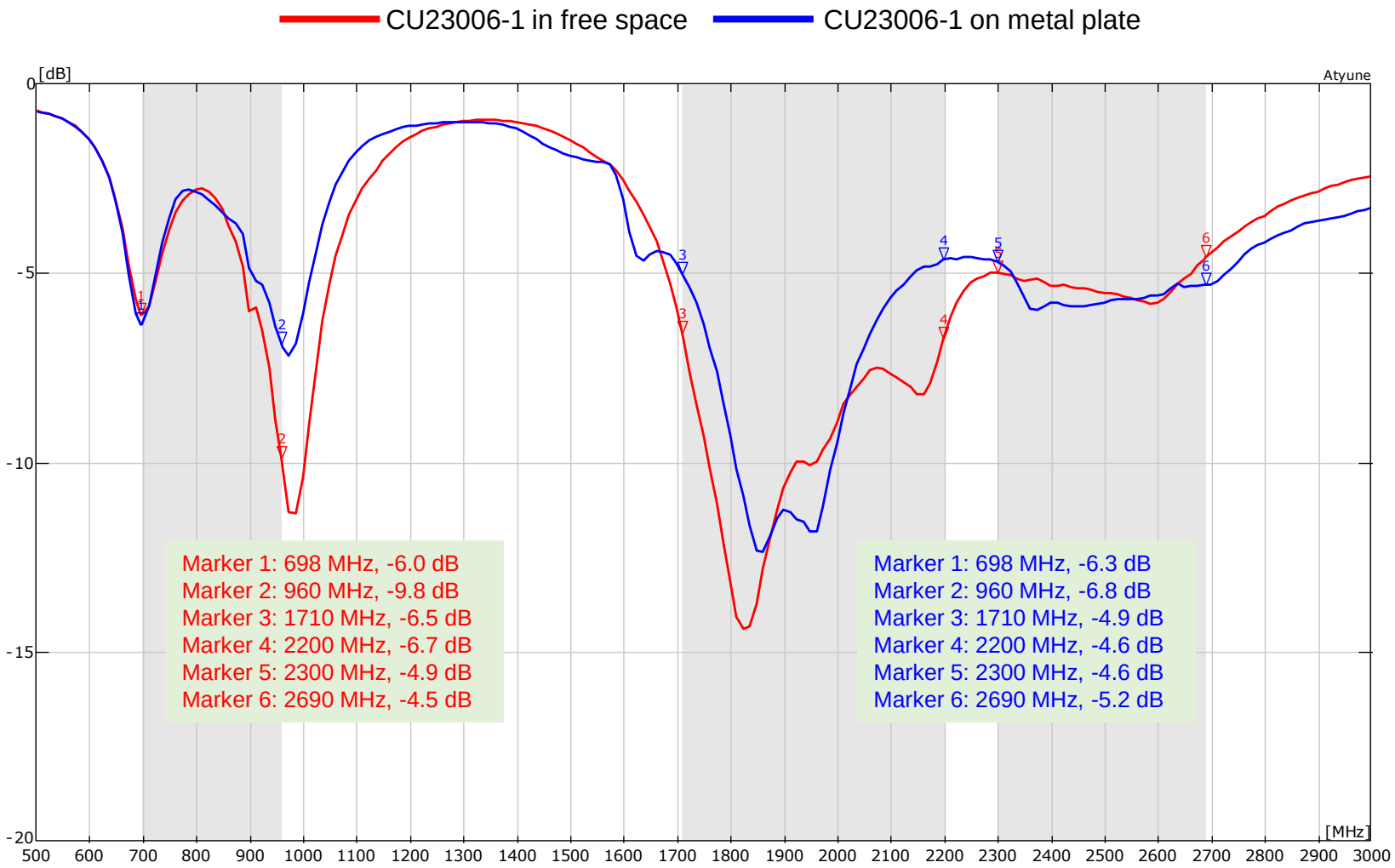


BOM (Bill of Materials)

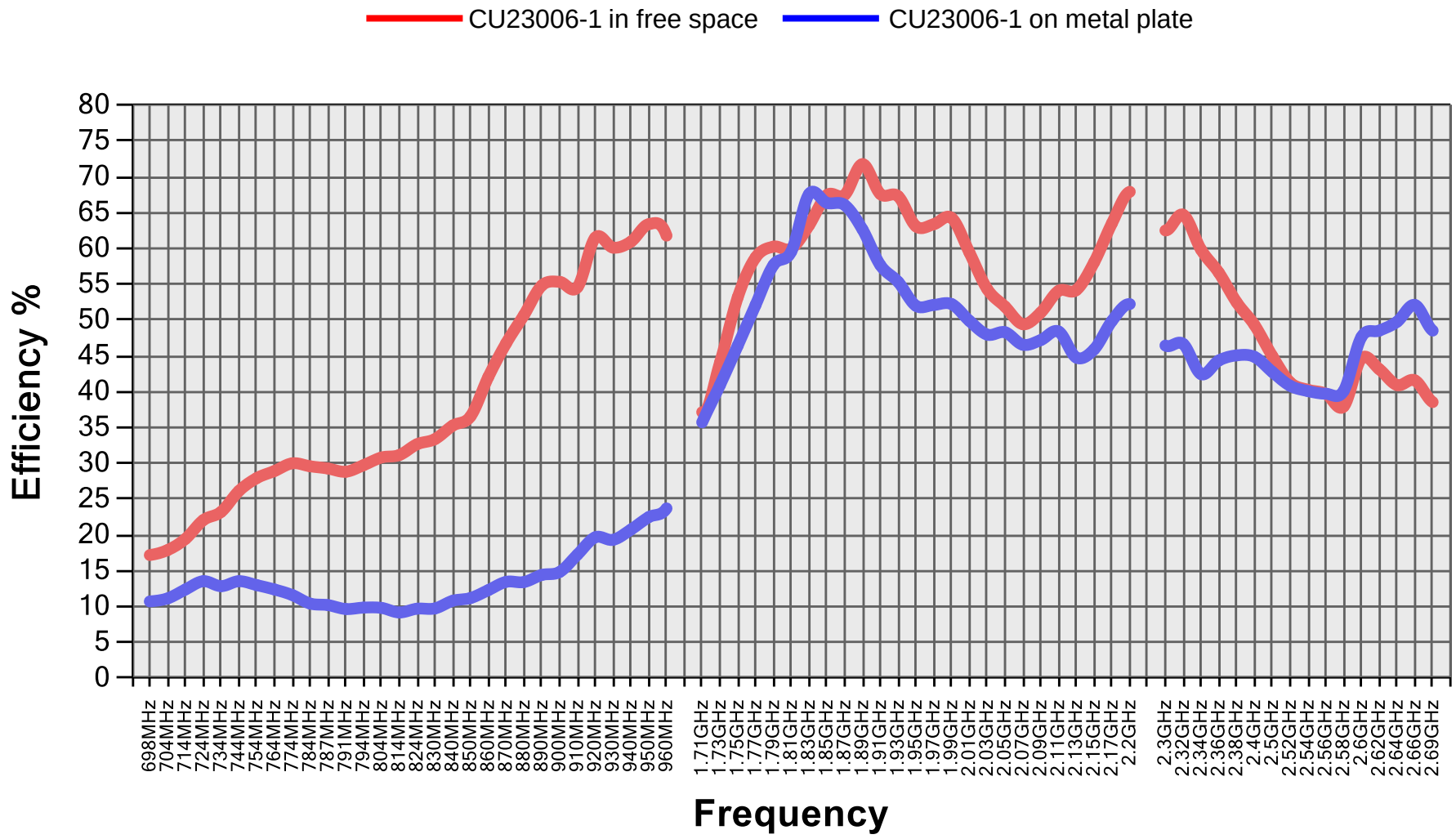
CU23006-1				
Designator	***Type***	***Value***	***Manufacturer***	***Series***
Z1	Inductor	47 nH	Murata	LQG15 series
Z2	Resistor	0 ohm	Non-Specific	Non-Specific
Z3	Inductor	7.5 nH	Murata	LQG15 series
Z4	Capacitor	3.6 pF	Murata	GJM15 series
Z5	Inductor	6.2 nH	Murata	LQG15 series

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.

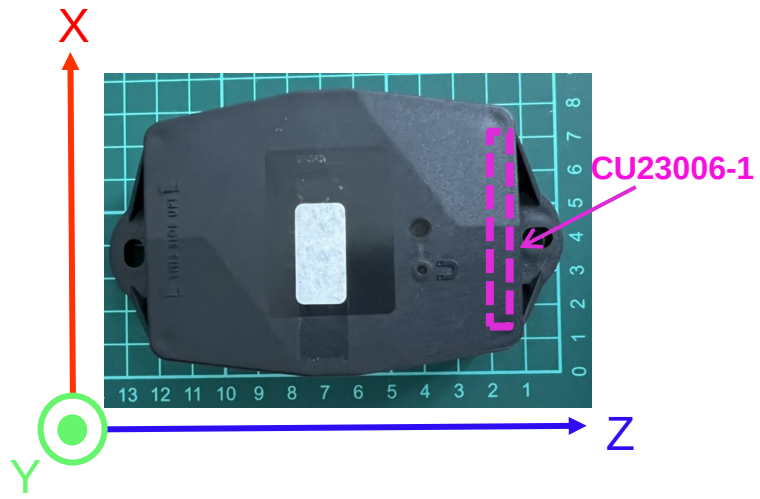
S-parameter

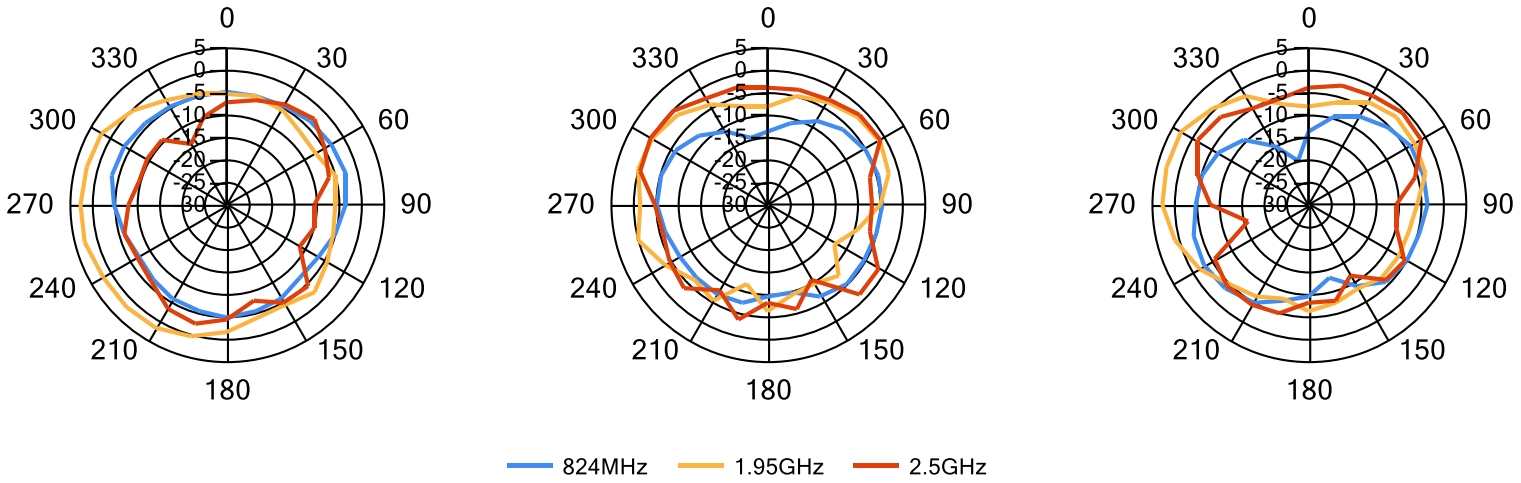

CU23006-1 in free space
CU23006-1 on metal plate
[dB]
Atyune
0
-5
-10
-15
-20
500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000
[MHz]
Marker 1: 698 MHz, -6.0 dB
Marker 2: 960 MHz, -9.8 dB
Marker 3: 1710 MHz, -6.5 dB
Marker 4: 2200 MHz, -6.7 dB
Marker 5: 2300 MHz, -4.9 dB
Marker 6: 2690 MHz, -4.5 dB
Marker 1: 698 MHz, -6.3 dB
Marker 2: 960 MHz, -6.8 dB
Marker 3: 1710 MHz, -4.9 dB
Marker 4: 2200 MHz, -4.6 dB
Marker 5: 2300 MHz, -4.6 dB
Marker 6: 2690 MHz, -5.2 dB

Antenna Efficiency

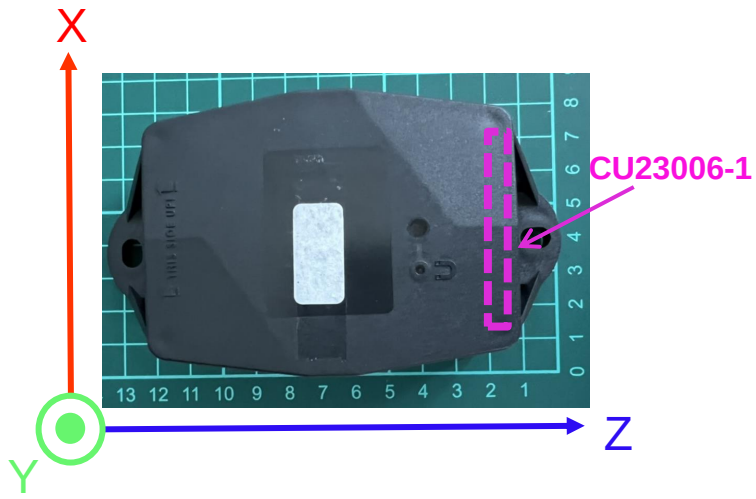


Antenna Radiation Pattern-2D-in free space

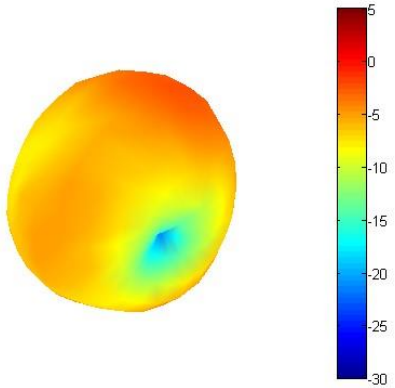




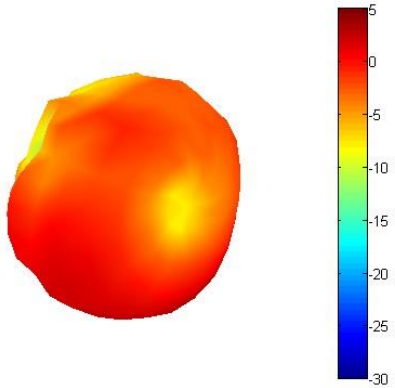
Antenna Radiation Pattern-3D-in free space



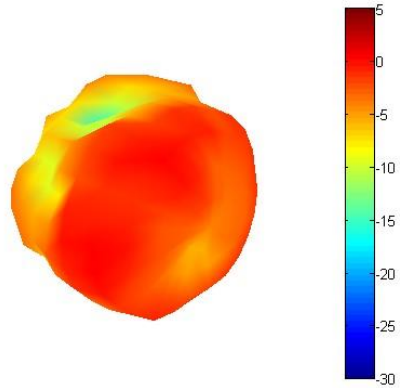
Patterns @ 824MHz



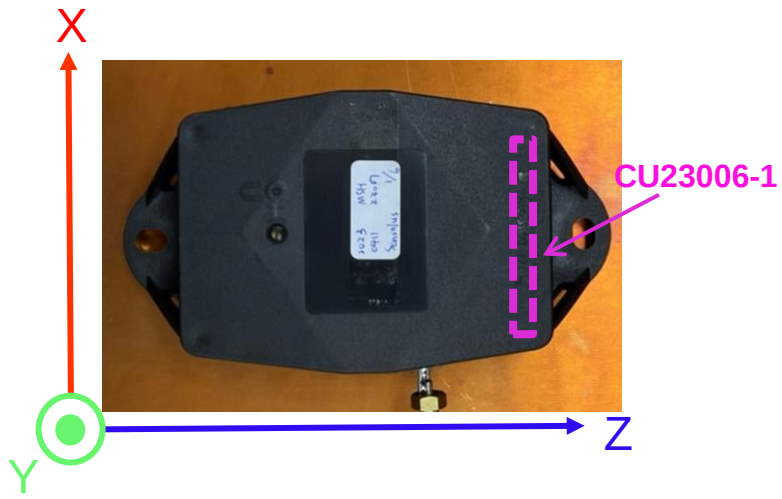
Patterns @ 1950MHz

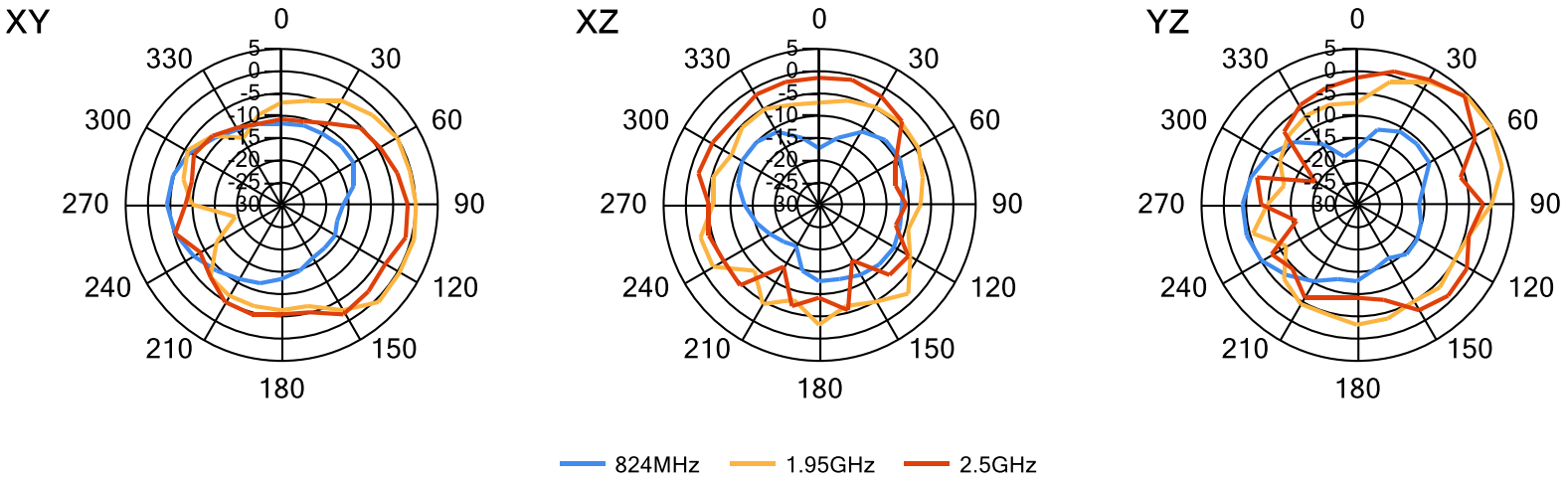


Patterns @ 2500MHz

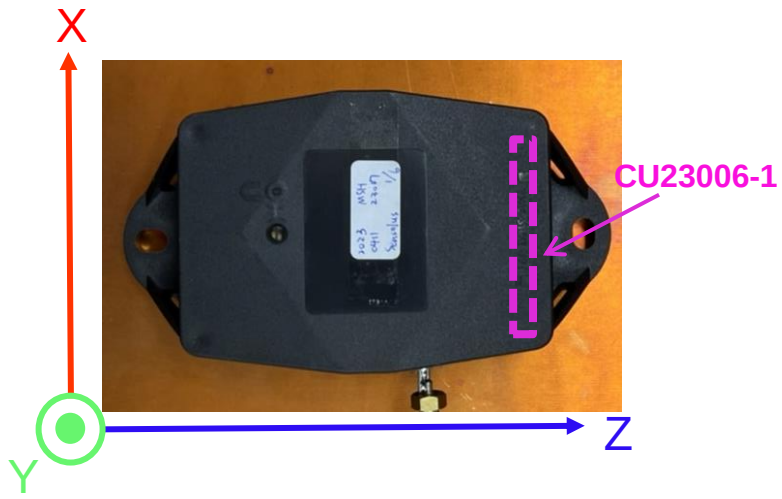


Antenna Radiation Pattern-2D-on metal plate

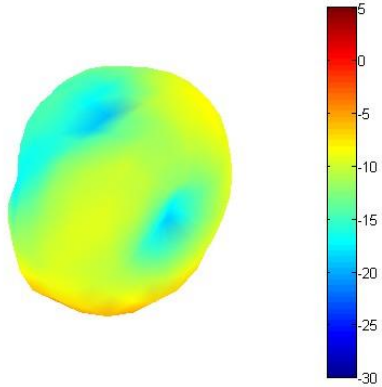




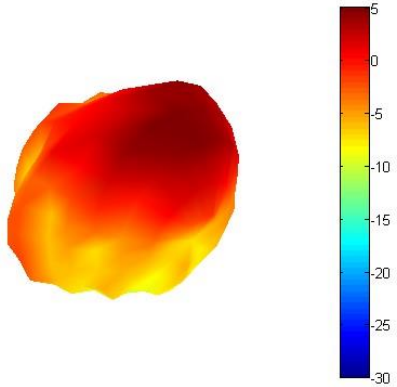
Antenna Radiation Pattern-3D-on metal plate



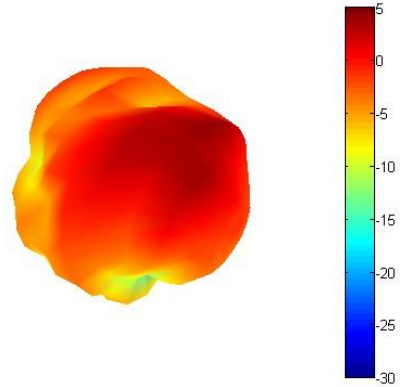
Patterns @ 824MHz



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.

Efficiency	*Antenna Gain $_{avg}$*	*2G 850/900*	*2G 1800/1900*	*3G*	*LTE*
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

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Statement on Intellectual Property

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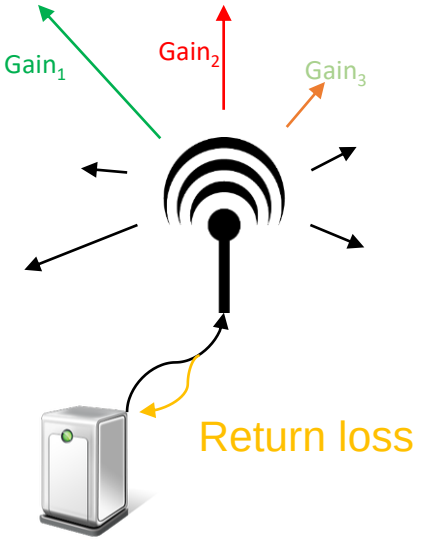
End of Document

Glossary

- **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.



$$\frac{1}{return \quad loss} \propto Efficiency \propto \frac{Gain_1 + Gain_2 + Gain_3 + ... + Gain_N}{N}$$