



APPENDIX J

: ANTENNA SPECIFICATION

1. Technical Information

1.1. Manufacturer Information

Manufacturer:	Guizhou KuaiGe Internet of Things Technology Co.,Ltd
Manufacturer Address:	D Block, 28th Floor, United Plaza, High-tech Zone, Guanshanhu District, Guiyang City, Guizhou Province

1.2. Equipment Under Test (EUT) Description

Wireless Type	Bluetooth
Frequency	2400MHz-2500MHz
IMEI	N/A
Sample No.	1#

1.3. Layout and Implementation

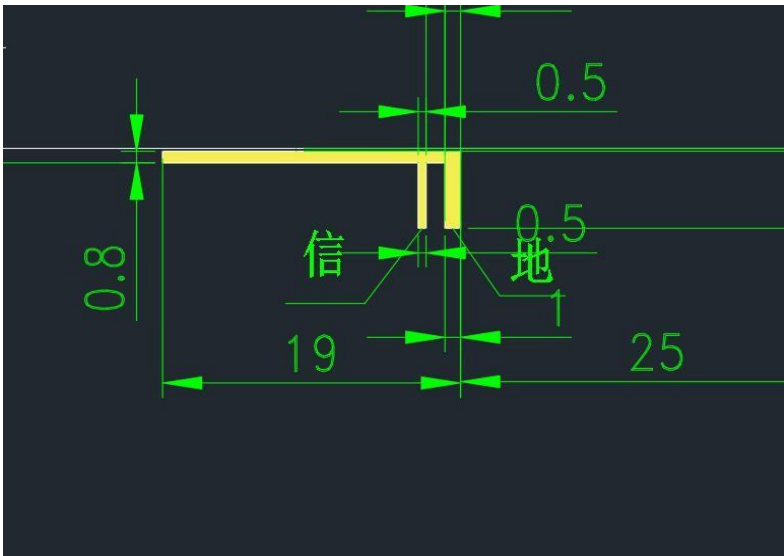


Figure 1: Antenna Dimensions

2. Test Results

Reflection, radiation pattern and variation of output power across a wide frequency band were measured to verify the performance of the PCB antenna. Free space is in this document interpreted as a measurement performed without connecting the EUT to a computer. In such a measurement the EUT is only powered by a battery.

2.1. Test Results lists

Frequency(MHz)	Gain(dBi)	Efficiency(%)
2400	-1.90	16.36
2410	-1.75	16.93
2420	-1.51	17.48
2430	-1.35	17.41
2440	-1.17	18.06
2450	-0.99	17.95
2460	-0.92	17.49
2470	-1.28	16.34
2480	-1.56	15.23
2490	-1.65	14.74
2500	-1.75	14.34

Table 2: Gain and Efficiency

Frequency (MHz)	VSWR	Impedance (Ω)
2400	1.93	83.65
2450	1.24	47.28
2500	2.27	22.73

Table 3: VSWR and Impedance

Frequency (MHz)	Return Loss (dB)
2400	-9.93
2450	-19.13
2500	-8.17

Table 4: Return Loss

2.2. Reflection

All the reflection measurements were performed with a network analyzer connected to a semi-rigid coax cable, which was soldered to the feed point of the antenna. Because of the small size antenna and the small ground plane this kind of measurements is heavily affected by the presence and placement of the coax cable. This influence can result in a small uncertainty in resonance frequency and measured reflection. Typically different placement of the semi-rigid coax cable could change the resonance frequency with 5 -10 MHz and the reflection with 3 - 4 dB.

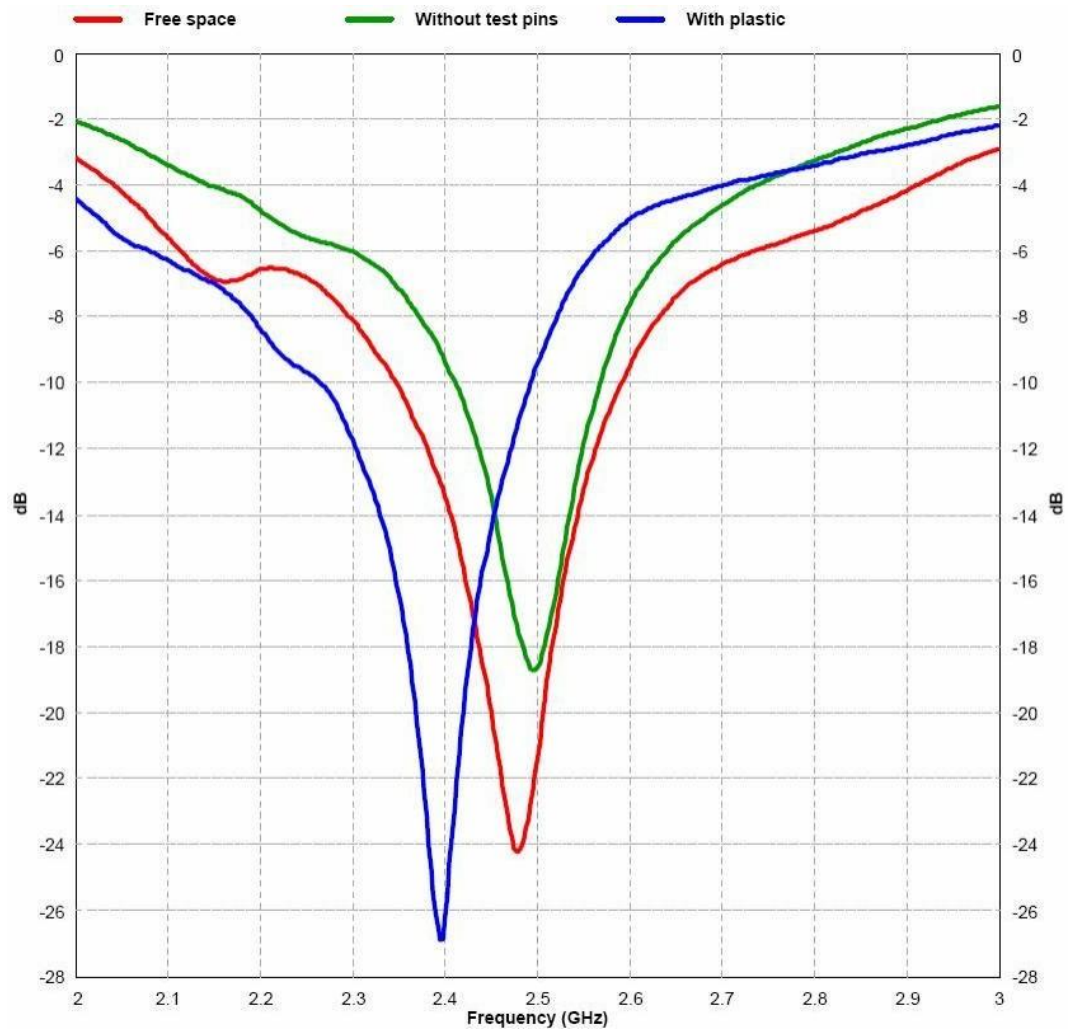


Figure 3: Influence of Plastic Encapsulation and Test Pins

2.3. Radiation Pattern

The radiation pattern for the antenna implemented on the EUT has been measured in an anechoic chamber. Figure 5 shows radiation patterns for three planes, XY, XZ and YZ, measured with vertical and horizontal polarization.

All these measurement were performed without connecting a computer. All measurements were performed with 0 dBm output power. Figure4 shows how the different radiation patters are related to the positioning of the antenna.

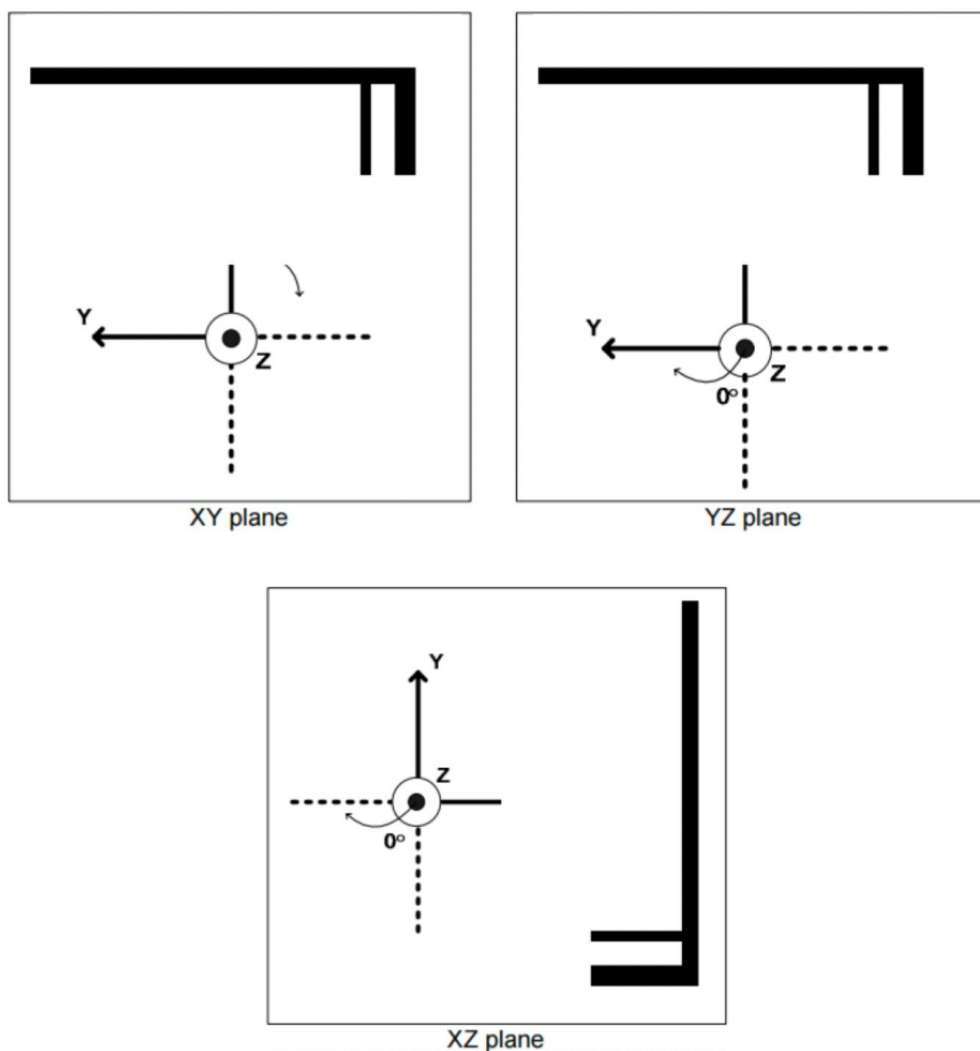


Figure 4: How to Relate the Antenna to the Radiation Patterns

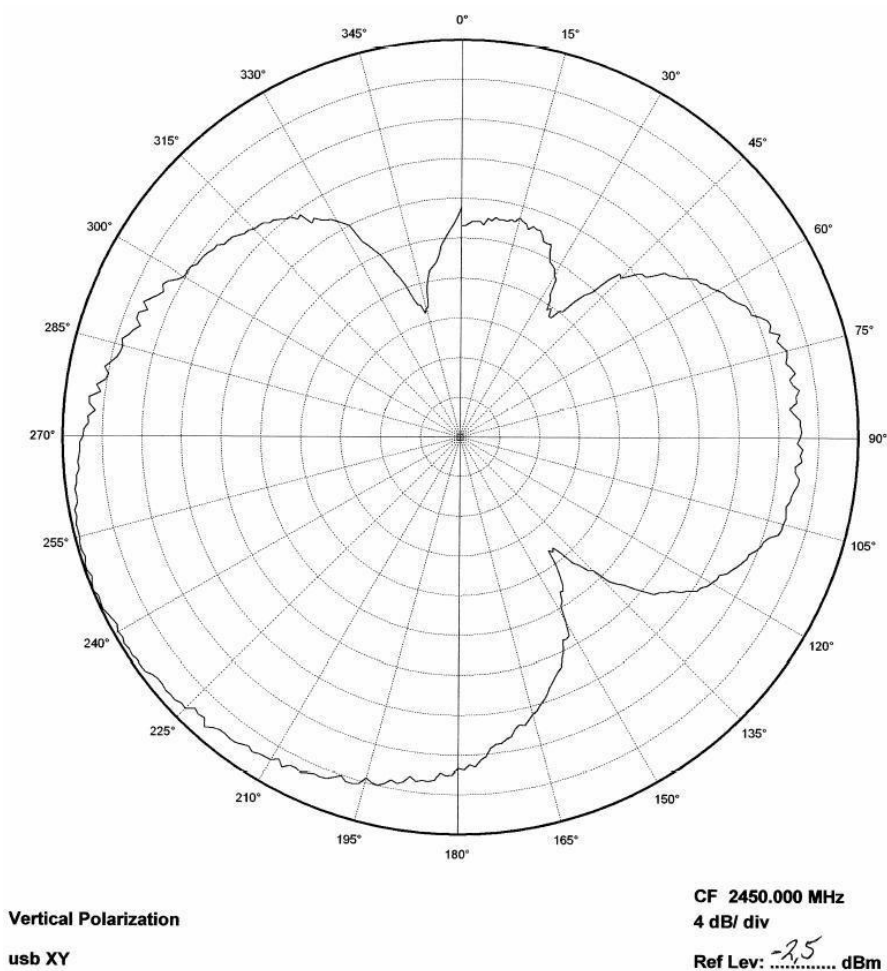


Figure 5: XY Plane

2.4. Output Power

To make a realistic bandwidth measurement of the antenna a small test program was used. The test program stepped the center frequency of a carrier from 2.3 to 2.8 GHz. This bandwidth measurement was also done to verify the result from the reflection measurements. The output power was measured using max hold on a spectrum analyzer. EUT was programmed for 0 dBm output power and the antenna was horizontally oriented and directed towards the receiving antenna. This corresponds to 0° in the XY plane on Figure 6.

broadband characteristic. Maximum output power is measured to be at 2.54 GHz. Thus if the same antenna is implemented on a PCB with similar size and if the application is only intended for stand alone usage the antenna could be made slightly longer to obtain best performance at 2.42 GHz.

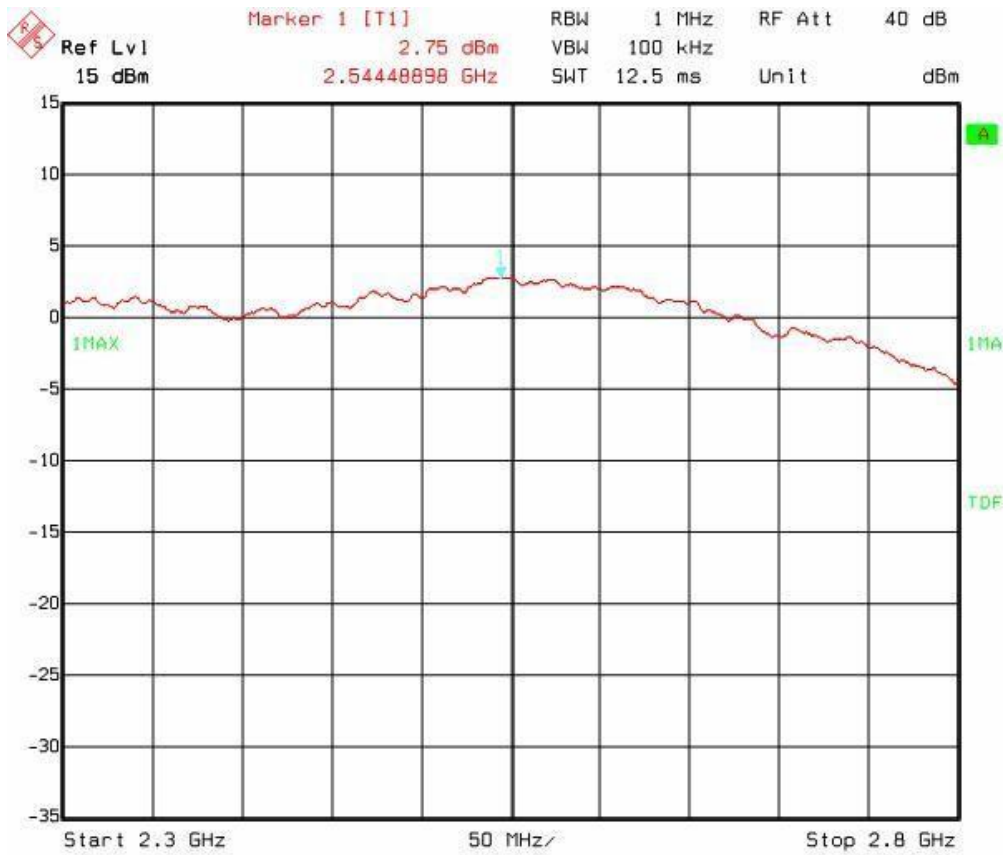


Figure 6: Output Power

2.5. Spurious Emission and Harmonics

Table 5 shows measured output power and emission at the second harmonic. Above the second harmonic no peaks were detected when measuring TX emission. These measurements were performed according to FCC requirements. An approximate conversion to dBm can be done by subtracting 95 from the measured value in dBμV/m. Since the measurement setup for ETSI and FCC is different this conversion will not give an exact result, but typically it will give a result that is within 1-2 dB of the result from a correct ETSI measurement.

Output power	2.44 GHz	4.88 GHz
1 dBm	96.9 dBμV/m	56.1 dBμV/m
0 dBm	96.1 dBμV/m	54.3 dBμV/m
-2 dBm	93.1 dBμV/m	52.5 dBμV/m

Table 5: Measured Level of Output Power and Harmonics

ETSI and FCC limits for output power and TX spurious emission are shown in Table 5. FCC allows for up to 20 dB higher emission if duty cycling is used. Thus, it is possible to use the antenna described in this document and be compliant with both ETSI and FCC regulation.

	EN 300 328	EN 300 440	FCC 15.247	FCC 15.249
2.4 – 2.483 GHz	20 dBm	10 dBm*	125 dB μ V/m 116 dB μ V/m**	94 dB μ V/m
2. harm	-30 dBm	-30 dBm	54 dB μ V m	54 dB μ V/m

*Depends on the power class.

** Depends on the number of channels being used.

Table 6: ETSI and FCC Limits

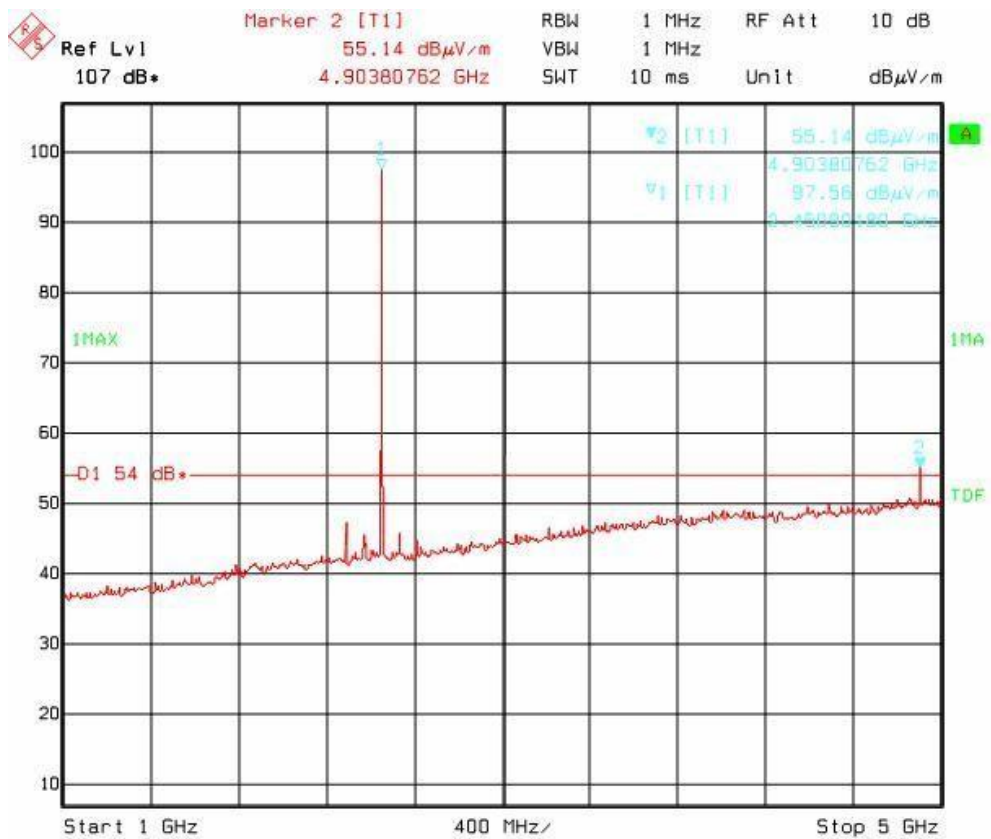


Figure 7: TX Spurious Emission 1 – 5 GHz

As opposed to FCC, ETSI has specific RX emission requirements. [Table 6](#) and Table 7 list the ETSI RX spurious requirements.

	Narrowband spurious emission	Wideband spurious emission
30 MHz to 1 GHz	-57 dBm	-107 dBm/Hz
1 GHz to 12.75 GHz	-47 dBm	-97 dBm/Hz

Table 7: EN 300 328 RX Spurious Requirements

25 MHz to 1 GHz	-57 dBm
1 GHz to 10 times the carrier frequency*	-47 dBm

*Applies for equipment operating between 1 GHz and 20 GHz.

Table 8: EN 300 440 RX Spurious Requirements

The only signal detected above the noise floor when measuring RX spurious emission was the VCO leakage at 4.89 GHz. Figure 8 shows that the measured VCO leakage is below ETSI limits.

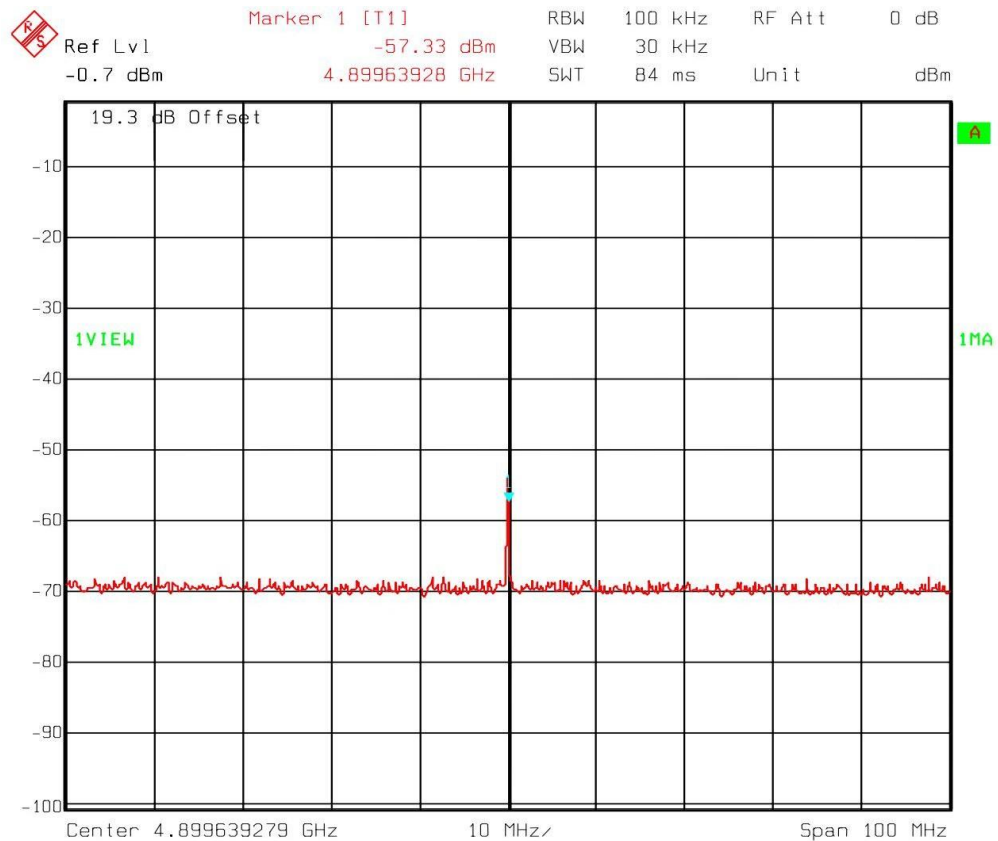


Figure 8: RX Spurious Emission