

TZ-80 Small Size 2.4 GHz PCB antenna

Manufacturer: Built-in PCB antenna

1 KEYWORDS

1.1 PCB antenna

1.2 2.4 GHz

1.3 Inverted F Antenna

2 INTRODUCTION

The PCB antenna used on the TZ-80 BLUETOOTH SPEAKER reference design is described in this application note. It can be used in all 2.4 GHz designs, especially where small space is required for the antenna.

This application note describes the antenna dimensions, the RF performance and considerations for complying with regulatory limits when using this design.

The suggested antenna design requires no more than 16.7 x 5.2 mm of space and ensures a VSWR ratio of less than 2 across the 2.4 GHz ISM band when connected to a 50 ohm source.

3 ABBREVIATIONS

IFA	Inverted F Antenna
ISM	Industrial, Scientific, Medical
LOS	Line Of Sight
PCB	Printed Circuit Board
PER	Packet Error Rate
VSWR	Voltage Standing Wave Ratio

4 ANTENNA DESIGN

The PCB antenna on the TZ-80 BLUETOOTH SPEAKER reference design is a meandered Inverted F Antenna (IFA). The IFA was designed to match an impedance of 50 ohm at 2.45 GHz. Thus no additional matching components are necessary.

4.1 Design Goals

The reflection at the feed point of the antenna determines how much of the applied power is delivered to the antenna. A reflection of less than -10 dB across the 2.4 GHz ISM band, when connected to a 50 ohm source, was a design goal. Reflection of less than -10 dB, or VSWR less than 2, ensures that more than 90% of the available power is delivered to the antenna.

4.2 Simulation

The antenna was designed using professional electromagnetic simulation software. Comparison of simulation and measurement results shows that the measured reflection is consistent with simulation data.

4.3 Layout and Implementation

Small changes of the antenna dimensions may have large impact on the performance. Therefore it is strongly recommended to make an exact copy of the reference design to achieve optimum performance.

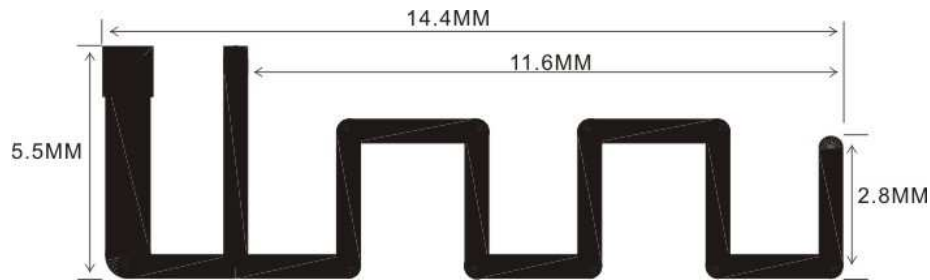


Figure 1: Antenna Dimensions

5 TEST RESULTS

Reflection, radiation pattern and output power were measured to verify the performance of the PCB antenna in free space, powered by battery only.

5.1 Reflection

All reflection measurements were performed with a network analyzer. The antenna has a bandwidth of approximately 250 MHz, which fully covers the 2.4 GHz ISM band.

Plastic encapsulation will shift the resonance frequency lower, which can be compensated by making the antenna slightly shorter.

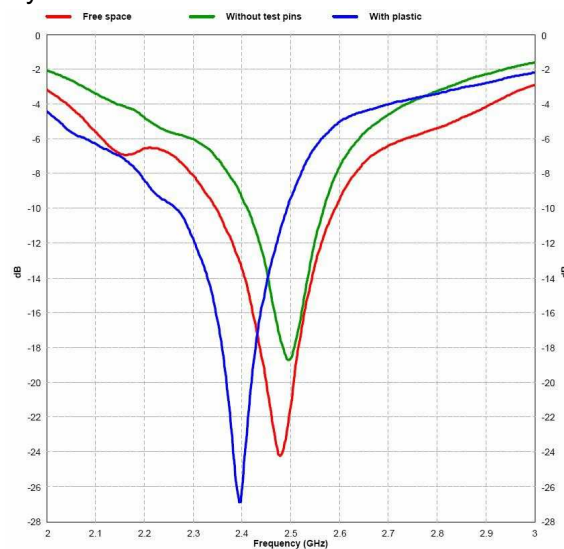


Figure 2: Influence of Plastic Encapsulation and Test Pins

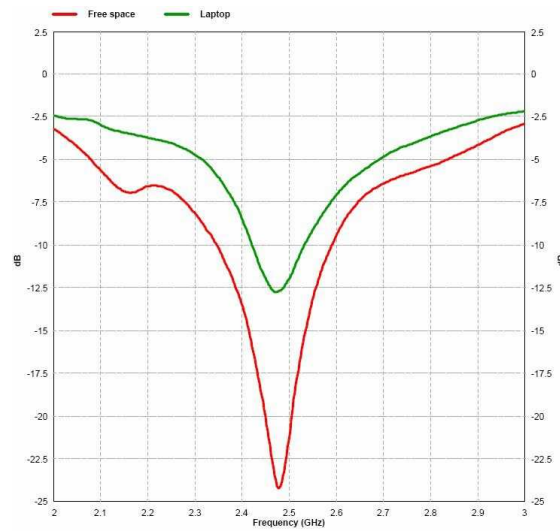


Figure 3: Comparison of Performance

5.2 Radiation Pattern

The radiation pattern was measured in an anechoic chamber. Figure 4 to Figure 10 show the radiation patterns for XY, XZ and YZ planes with vertical and horizontal polarization. All measurements were performed with 0 dBm output power.

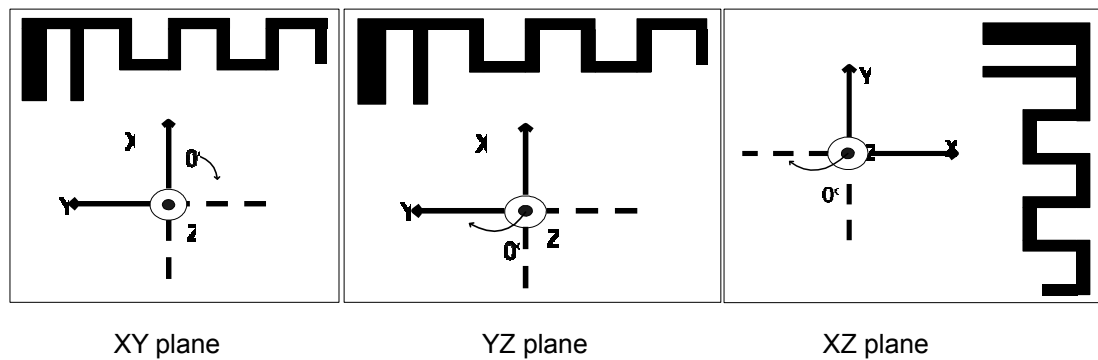


Figure 4: How to Relate the Antenna to the Radiation Patterns

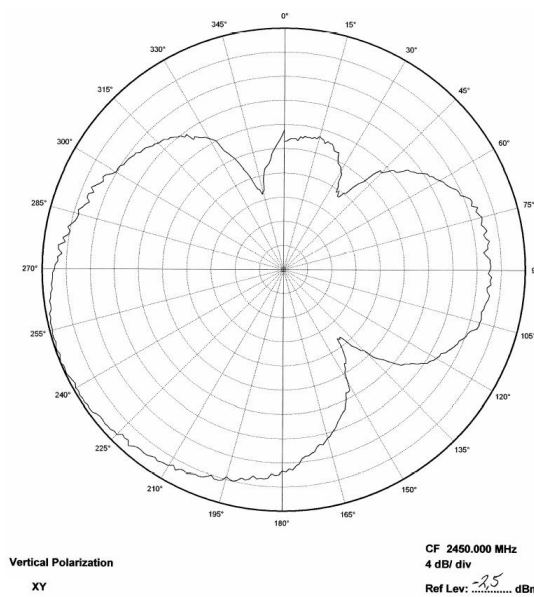


Figure 5: TZ-80 BLUETOOTH SPEAKER XY Plane

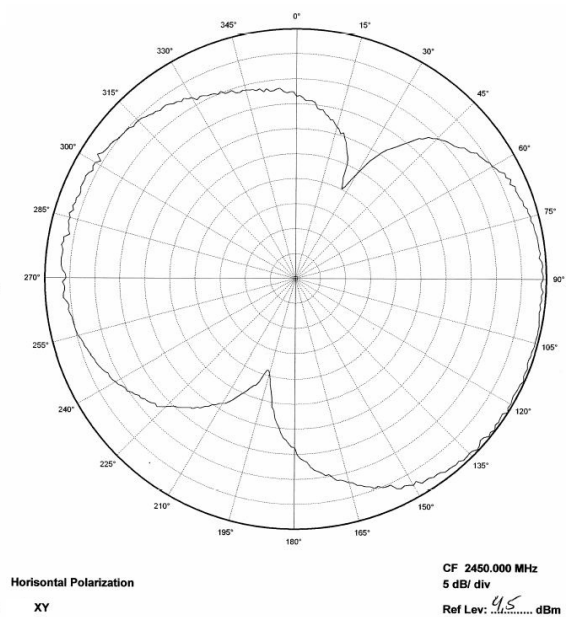


Figure 6: TZ-80 BLUETOOTH SPEAKER XY Plane

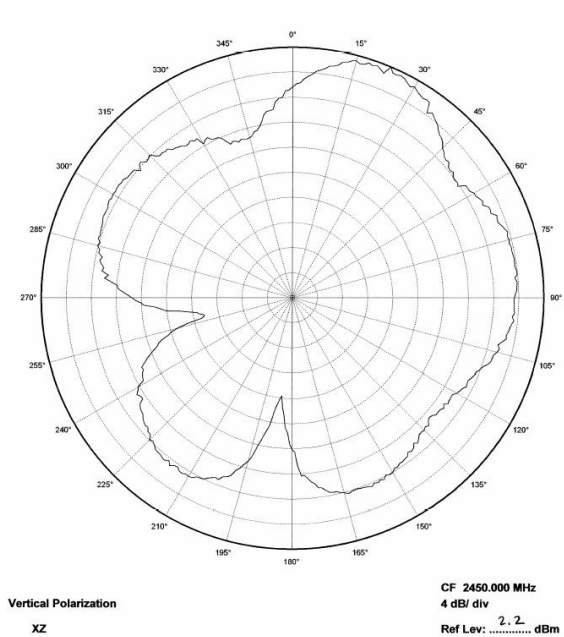


Figure 7: TZ-80 BLUETOOTH SPEAKER XZ Plane

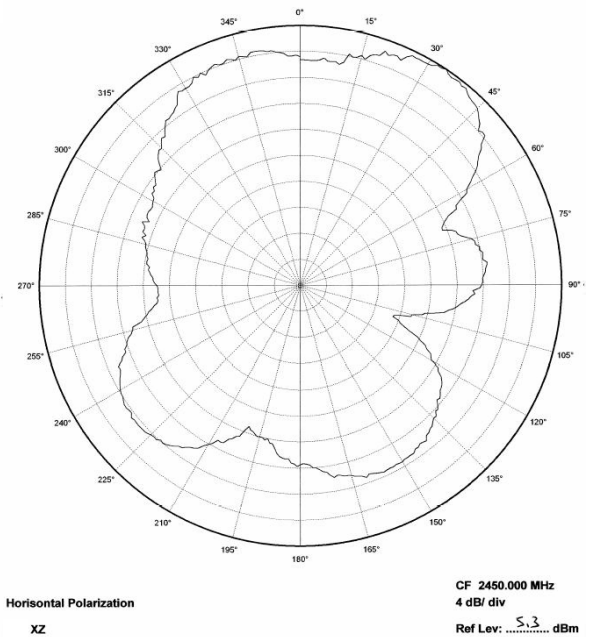


Figure 8: TZ-80 BLUETOOTH SPEAKER XZ Plane

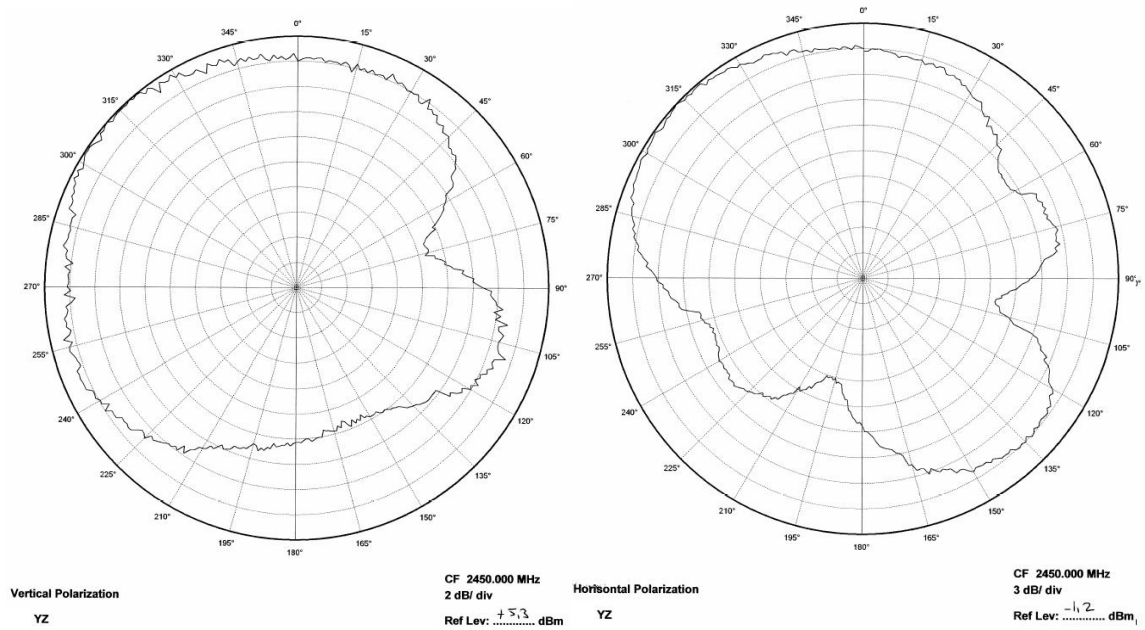


Figure 9: TZ-80 BLUETOOTH SPEAKER YZ Plane

Figure 10: TZ-80 BLUETOOTH SPEAKER YZ Plane

5.3 Output Power

The antenna has a variation in output power of less than 3 dB across a bandwidth wider than 350 MHz, showing excellent broadband performance. Maximum output power is measured at 2.54 GHz.



Figure 13: Output Power, TZ-80 BLUETOOTH SPEAKER

5.4 Spurious Emission and Harmonics

Table 2 shows measured output power and emission at the second harmonic. No significant peaks were detected above the second harmonic.

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

Table 1: Measured Level of Output Power and Harmonics

	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	94 dB μ V/m
2nd harmonic	-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 2: ETSI and FCC Limits

5.5 Antenna Peak Gain vs Frequency

Frequency (MHz)	Peak Gain (dBi)
2402	4.2
2412	4.3
2422	4.4
2432	4.5
2442	4.5
2452	4.5
2462	4.4
2472	4.3
2482	4.2

Table 3: Peak Gain vs Frequency

6 CONCLUSION

This application note shows that it is possible to implement a high-performance 2.4 GHz PCB antenna in a very small size for Bluetooth speaker applications.

Gain in XY plane	4.5 dB
Gain in XZ plane	5.3 dB
Gain in YZ plane	5.3 dB
LOS range	10 m
Antenna size	16.7 x 5.2 mm

Table 4: IFA Properties

Test results demonstrate that the antenna fully complies with ETSI and FCC regulations for 2.4 GHz Bluetooth devices