

600 946 Assa HES V3 BLE

K100 - UHF and BLE antenna measurements

Doc.no: 3-3-TR-600 946-01

Revision History

Date	Rev.	Author	Description
2018-06-27	PA1	Pär Berglund	First draft

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1 Introduction

This document presents antenna measurements for the internal antennas within the ASSA HES V3 BLE K100 door lock.



Figure 1 ASSA HES K100

The measurements are done including the parts stated below:

Lock body	K100
Main board #1	3080043.029 v0.3
Main board #2	3080043.028 v0.3
BLE module	rev 2
Interface board	3080043.027 v0.3
13.56MHz RFID coil	3080043.025/PCB 00183 v.A



Figure 2 Assembly of main board #1 3080043.029 v0.3 and main board #2 3080043.028 v0.3



Figure 3 BLE module and interface board 3080043.027 v0.3



Figure 4 RFID coils assembly (13,56MHz 3080043.025/PCB 00183 v.A)

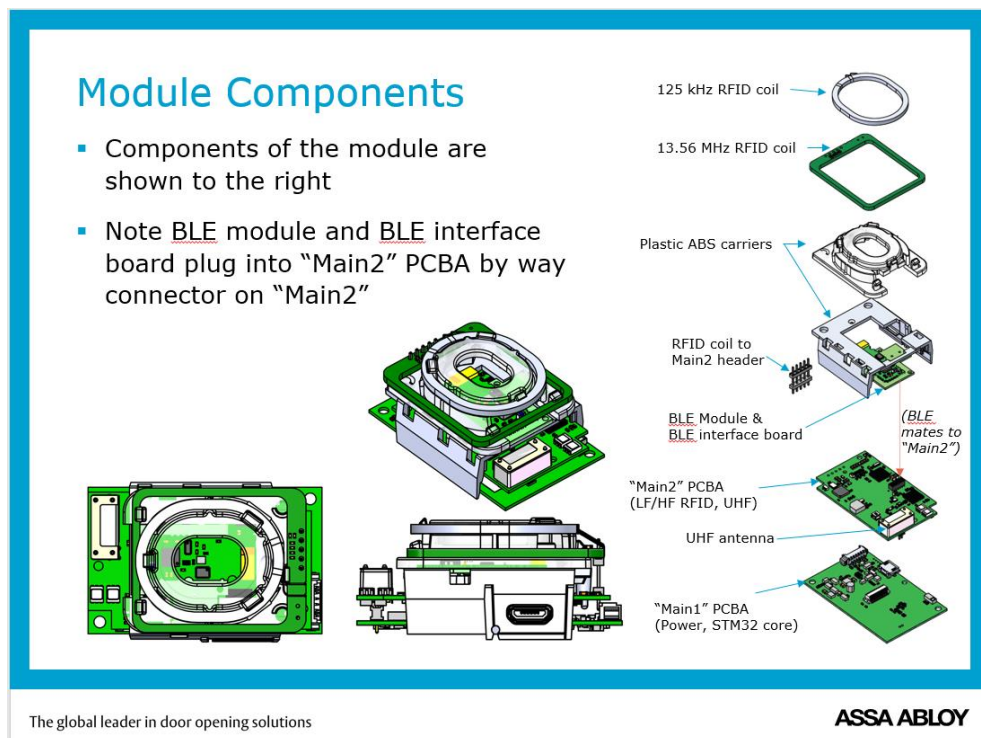


Figure 5 Assembly sketch

2 Antenna measurements

The antenna performance is characterized in terms of Voltage Standing Wave Ratio (VSWR), antenna efficiency and radiation patterns.

The antenna efficiency, ϵ_T , is the ratio of the power delivered at the 50 Ω antenna interface, P_t , relative to the power radiated from the antenna, $P_{radiated}$.

$$\epsilon_T = \frac{P_{radiated}}{P_t}$$

The antenna efficiency can be expressed in dB or %, where 100% corresponds to 0dB. The antenna efficiency measurements are carried out in a *scattered field chamber*.

Measurements with three configurations for the BLE module have been examined. Initial configuration (no modifications), no matching components and optimized BLE antenna matching.

2.1 UHF and BLE as standalone

To show how the assembly and mechanics affect the tuning of the antenna's, a VSWR reference measurement has been performed on the antennas as standalone (BLE module mounted on interface board, UHF antenna mounted on main board #1 that is connected to main board #2)

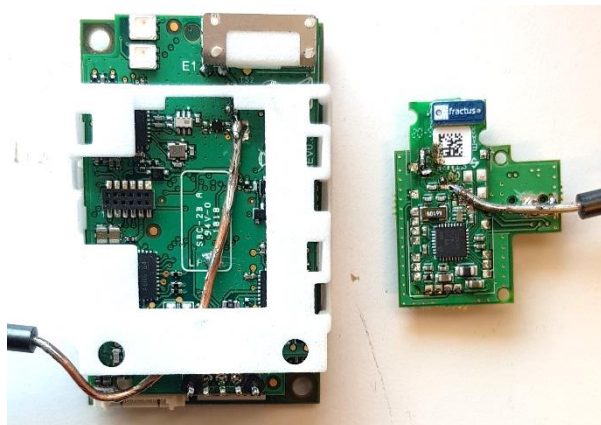


Figure 6 UHF and BLE standalone

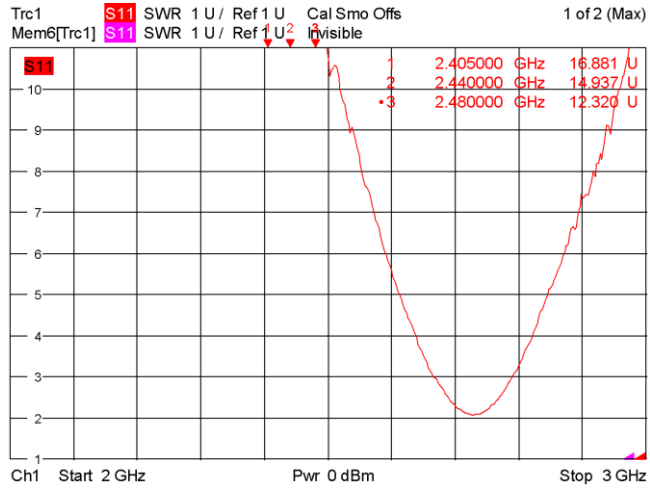


Figure 7 VSWR BLE antenna – module standalone

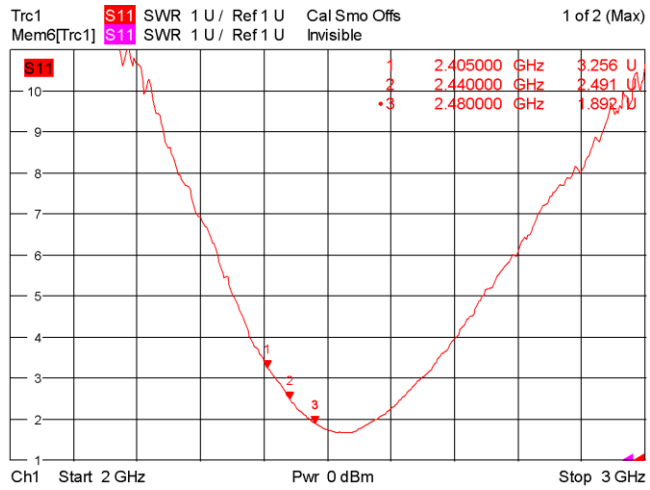


Figure 8 VSWR UHF antenna – standalone

2.2 Initial configuration

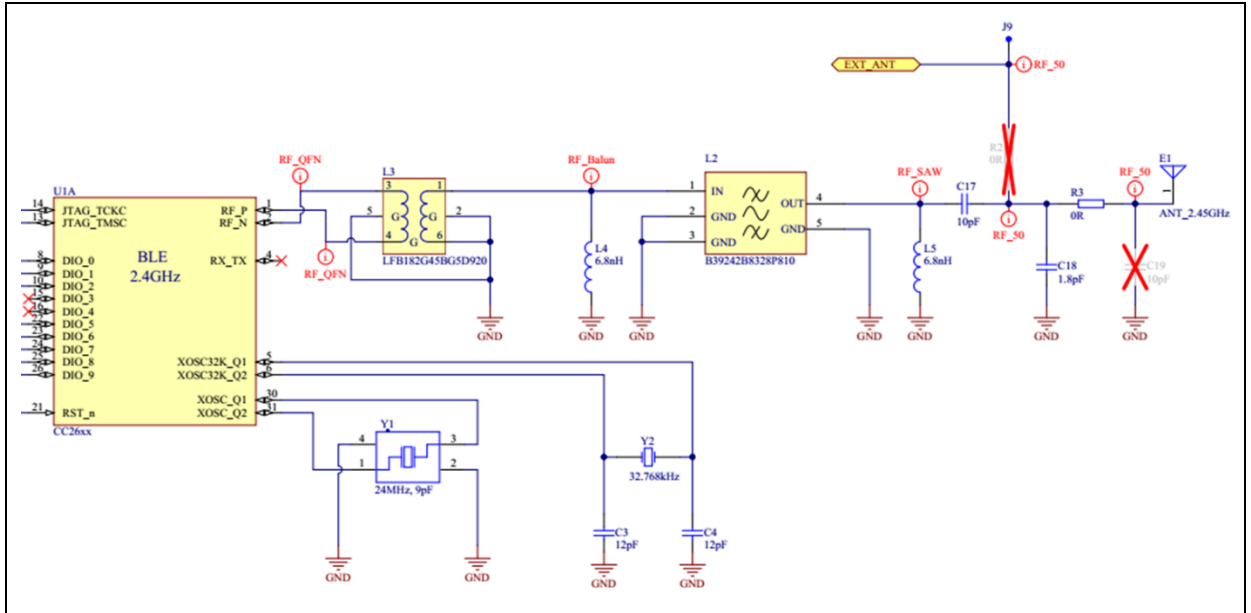


Figure 9 Schematic BLE antenna matching - initial configuration

2.2.1 VSWR - initial configuration

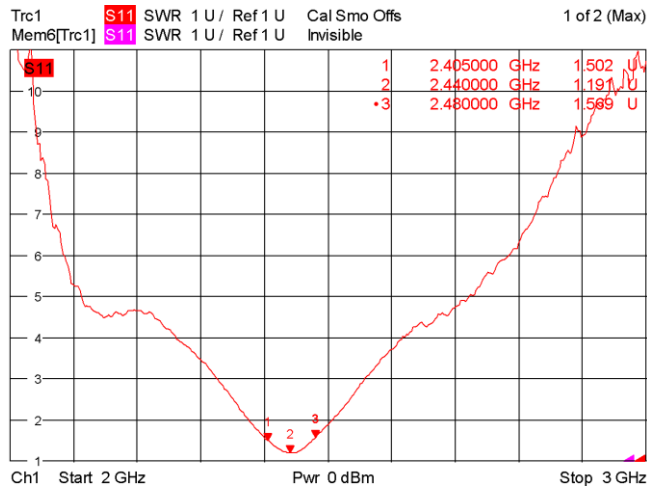


Figure 10 VSWR UHF antenna - initial configuration

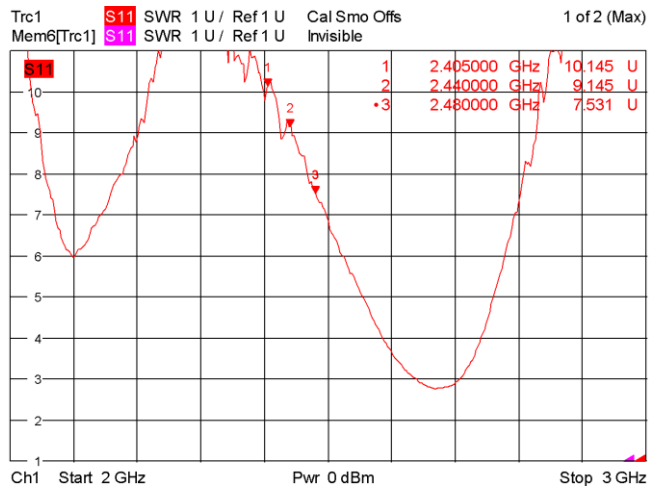


Figure 11 VSWR BLE antenna – initial configuration

2.2.2 Antenna efficiency – initial configuration

Table 1 Antenna efficiency UHF and BLE antennas– initial configuration

Freq [MHz]	UHF Antenna efficiency		BLE Antenna efficiency	
	[%]	[dB]	[%]	[dB]
2405	40	-4.0	5	-12.9
2440	47	-3.3	5	-13.3
2480	48	-3.2	6	-12.2

2.3 No BLE antenna matching

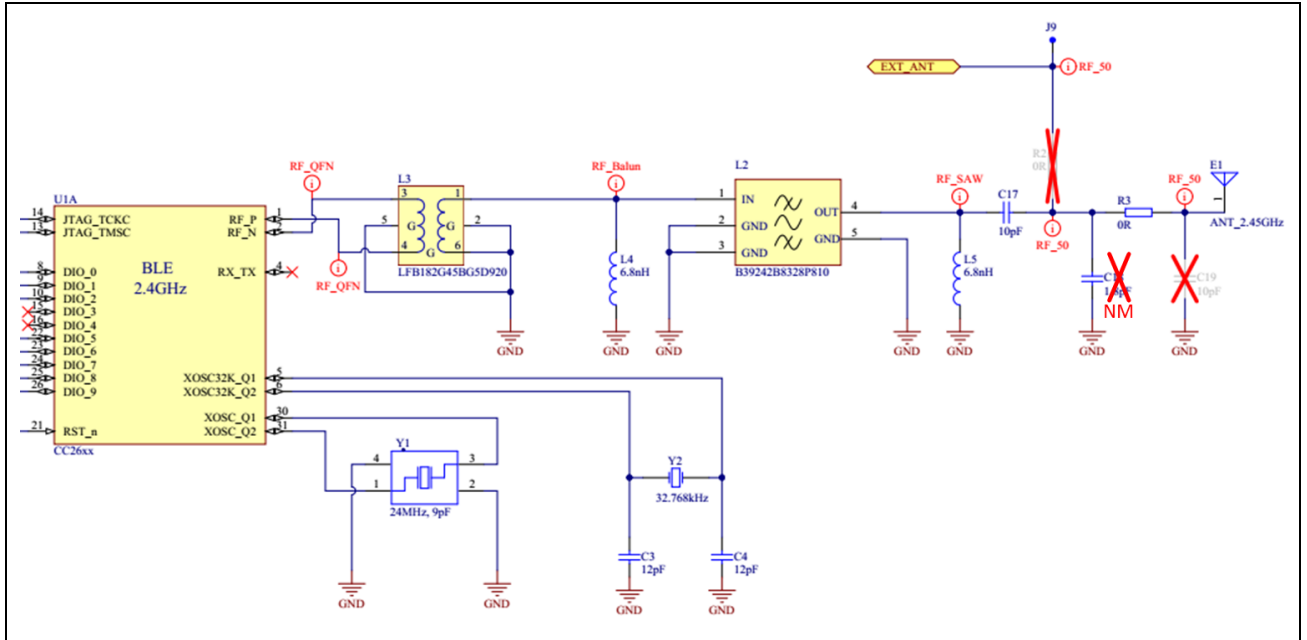


Figure 12 C18 (1p8) removed

2.3.1 VSWR - No BLE antenna matching

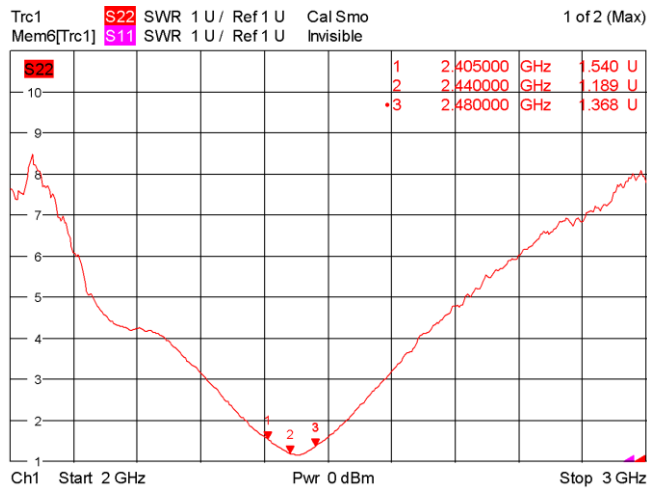


Figure 13 VSWR UHF antenna - NO BLE antenna matching

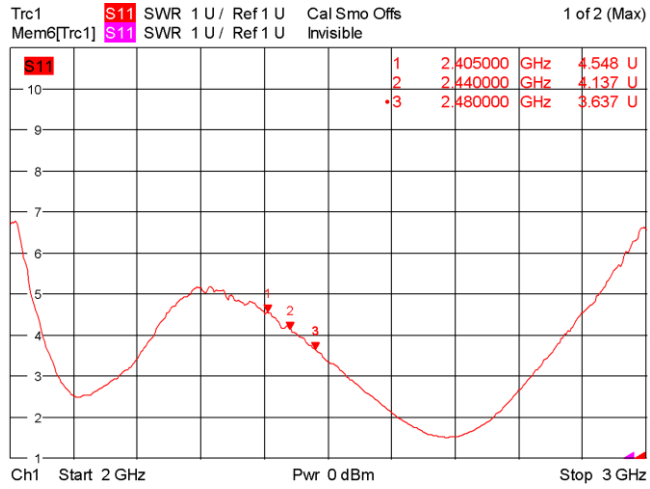


Figure 14 VSWR BLE antenna - NO BLE antenna matching

2.3.2 Antenna efficiency - No BLE antenna matching

Table 2 Antenna efficiency UHF and BLE antennas- No BLE antenna matching

Freq [MHz]	UHF Antenna efficiency		BLE Antenna efficiency	
	[%]	[dB]	[%]	[dB]
2405	40	-4.0	10	-10.0
2440	44	-3.6	10	-10.2
2480	46	-3.4	11	-9.6

2.4 Optimized BLE antenna matching

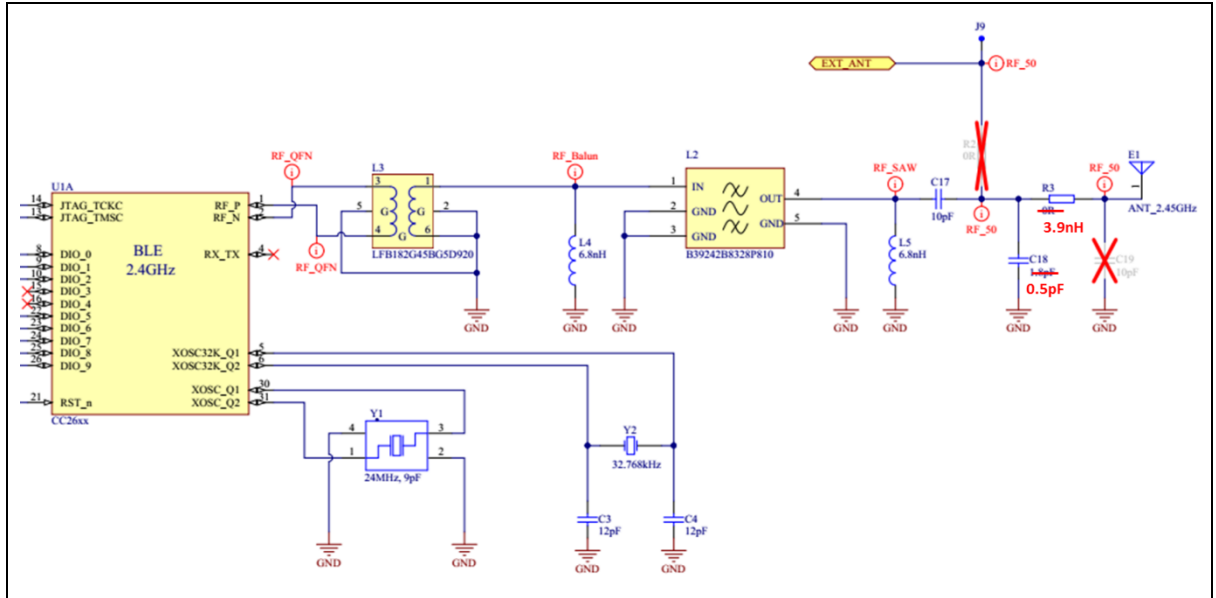


Figure 15 Matching circuit – optimized BLE antenna matching. C18 changed from 1.8pF to 0.5pF, R3 changed from 0ohm to 3.9nH

2.4.1 VSWR - Optimized BLE antenna matching

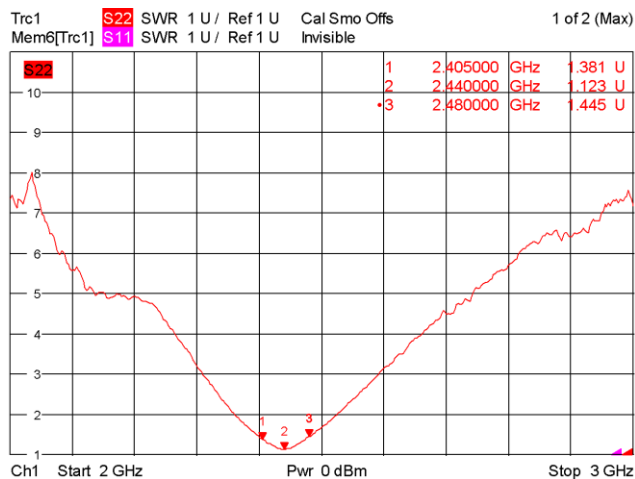


Figure 16 VSWR UHF antenna – Optimized BLE matching

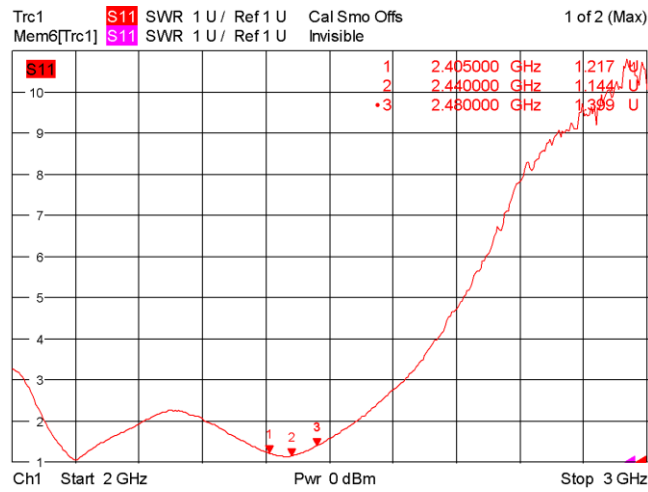


Figure 17 VSWR BLE antenna – Optimized BLE matching

2.4.2 Antenna efficiency – Optimized BLE antenna matching

Table 3 Antenna efficiency UHF and BLE antennas– No BLE matching

Freq [MHz]	UHF Antenna efficiency		BLE Antenna efficiency	
	[%]	[dB]	[%]	[dB]
2405	38	-4.2	16	-8.0
2440	42	-3.8	17	-7.8
2480	44	-3.6	15	-8.3

2.5 Antenna efficiency - Summary

The antenna efficiency, ϵ_T , is the ratio of the power delivered at the 50Ω antenna interface, P_t , relative to the power radiated from the antenna, $P_{radiated}$.

$$\epsilon_T = \frac{P_{radiated}}{P_t}$$

The antenna efficiency can be expressed in dB or %, where 100% corresponds to 0dB. The antenna efficiency measurements are carried out in a *scattered field chamber*.

Antenna efficiency - initial configuration

Table 4 Antenna efficiency UHF and BLE antennas- initial configuration

Freq [MHz]	UHF Antenna efficiency		BLE Antenna efficiency	
	[%]	[dB]	[%]	[dB]
2405	40	-4.0	5	-12.9
2440	47	-3.3	5	-13.3
2480	48	-3.2	6	-12.2

Antenna efficiency - No BLE antenna matching

Table 5 Antenna efficiency UHF and BLE antennas- No BLE antenna matching

Freq [MHz]	UHF Antenna efficiency		BLE Antenna efficiency	
	[%]	[dB]	[%]	[dB]
2405	40	-4.0	10	-10.0
2440	44	-3.6	10	-10.2
2480	46	-3.4	11	-9.6

Antenna efficiency - Optimized BLE antenna matching

Table 6 Antenna efficiency UHF and BLE antennas- No BLE matching

Freq [MHz]	UHF Antenna efficiency		BLE Antenna efficiency	
	[%]	[dB]	[%]	[dB]
2405	38	-4.2	16	-8.0
2440	42	-3.8	17	-7.8
2480	44	-3.6	15	-8.3

3 Radiation patterns

The antenna radiation pattern measurements are carried out in an anechoic chamber. Patterns are presented for three measurement planes: XY-, XZ- and YZ-planes. The measurements are carried out with horizontal and vertical polarization of the receiving antenna for each position of the DUT (Figure 19)

Measurements are performed for the K100 as standalone and when mounted on a mock-up of a metal door.



Figure 18: Measurements plane definitions

In this section the total antenna gain is presented. The total antenna gain G_{ANT} is defined as the sum of the horizontal G_{ANT-H} and vertical component G_{ANT-V} , i.e. a power-wise addition of the horizontal and vertical components.

$$G_{ANT} = 10 \log_{10} \left(10^{\frac{G_{ANT-H}}{10}} + 10^{\frac{G_{ANT-V}}{10}} \right)$$

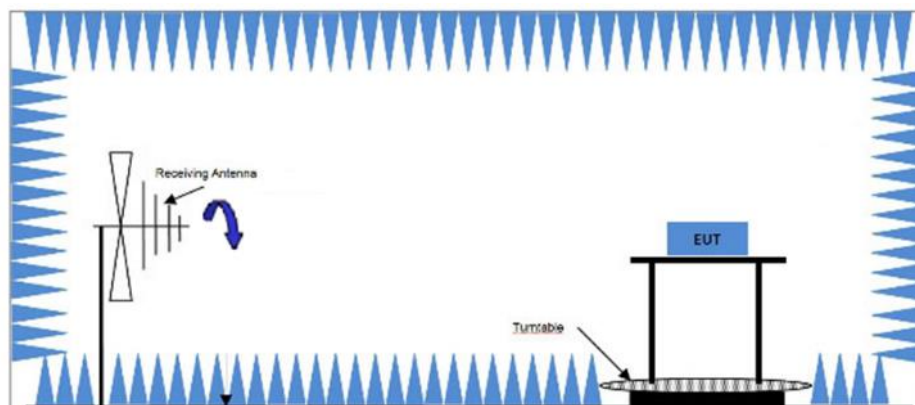


Figure 19 Radiation pattern measurements with horizontal and vertical polarization of receiving antenna.

In addition to radiation patterns for total antenna gain, patterns for vertical and horizontal polarizations are presented in Appendix A

3.1 UHF

HES V3 BLE standalone

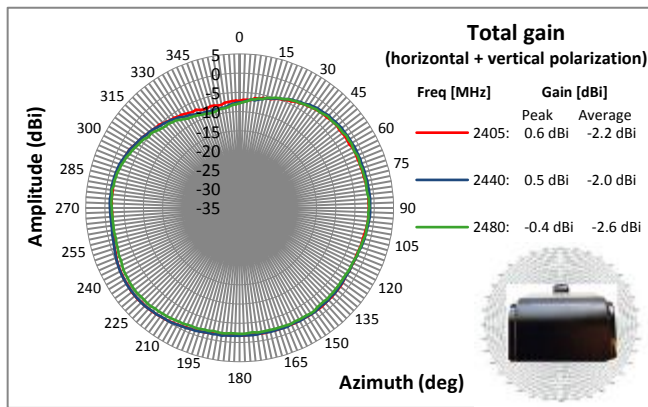


Figure 20 XY plane radiation pattern for UHF antenna, total gain (horizontal + vertical polarisation). K100 standalone

HES V3 BLE mounted on metal door mock-up

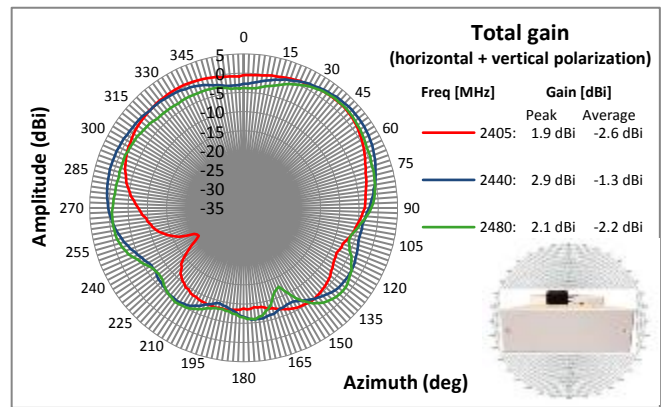


Figure 21 XY plane radiation pattern for UHF antenna, total gain (horizontal + vertical polarisation). K100 mounted on metal door

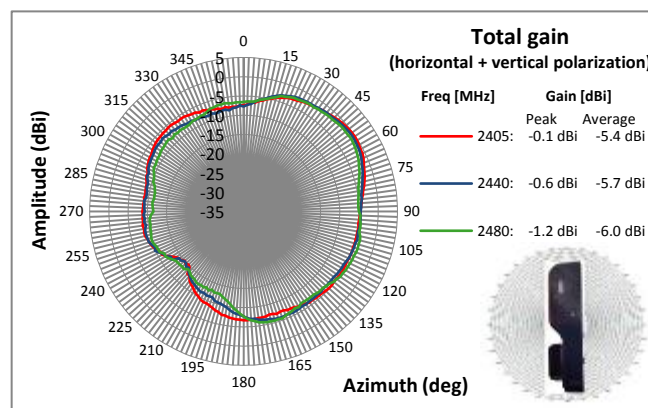


Figure 22 YZ plane radiation pattern for UHF antenna, total gain (horizontal + vertical polarisation). K100 standalone

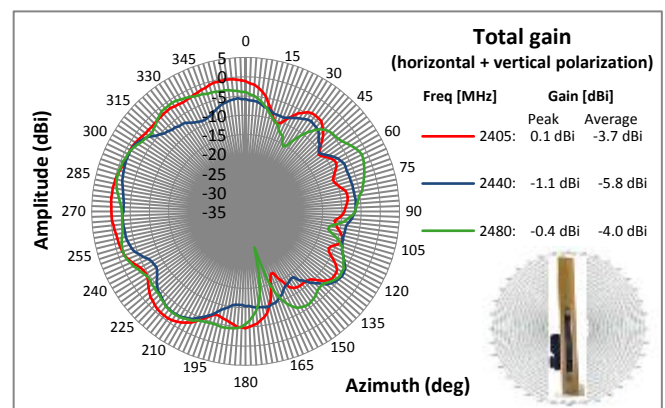


Figure 23 YZ plane radiation pattern for UHF antenna, total gain (horizontal + vertical polarisation). K100 mounted on metal door

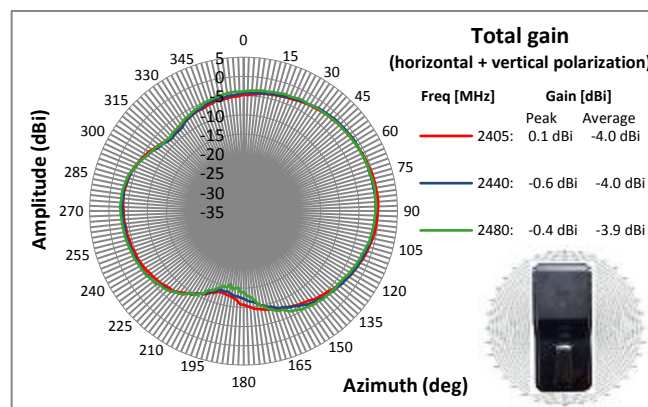


Figure 24 XZ plane radiation pattern for UHF antenna, total gain (horizontal + vertical polarisation). K100 standalone

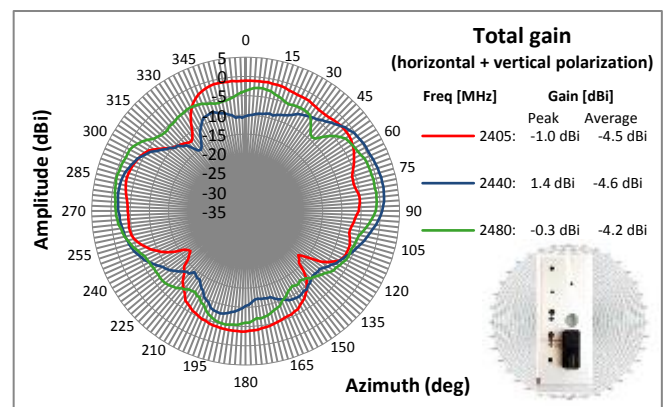


Figure 25 XZ plane radiation pattern for UHF antenna, total gain (horizontal + vertical polarisation). K100 mounted on metal door

3.2 BLE – initial configuration

HES V3 BLE standalone

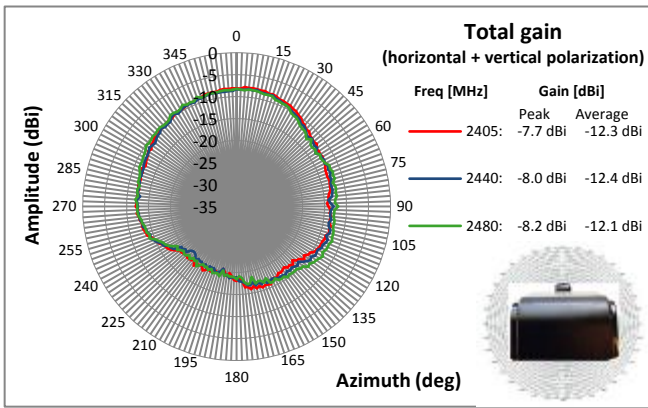


Figure 26 XY plane radiation pattern for BLE antenna initial configuration, total gain (horizontal + vertical polarisation). K100 standalone

HES V3 BLE mounted on metal door mock-up

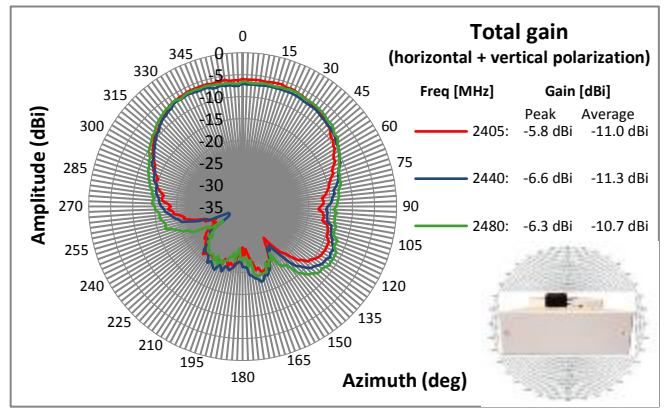


Figure 27 XY plane radiation pattern for BLE antenna initial configuration, total gain (horizontal + vertical polarisation). K100 mounted on metal door

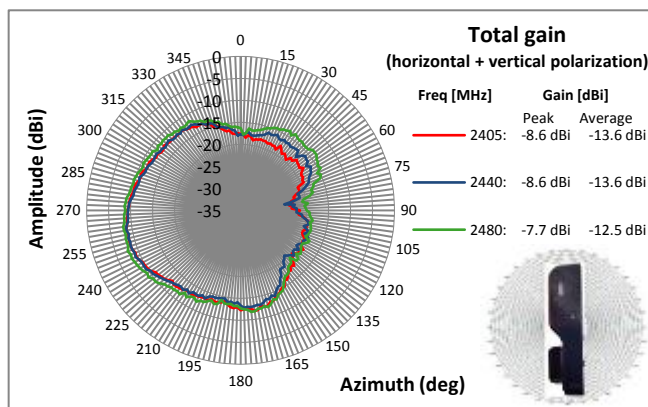


Figure 28 YZ plane radiation pattern for BLE antenna initial configuration, total gain (horizontal + vertical polarisation). K100 standalone

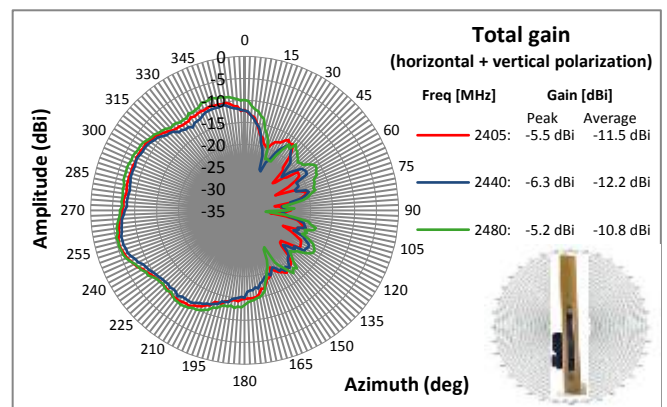


Figure 29 YZ plane radiation pattern for BLE antenna initial configuration, total gain (horizontal + vertical polarisation). K100 mounted on metal door

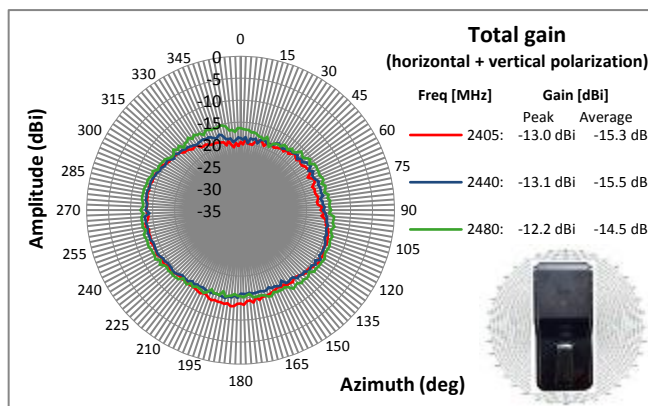


Figure 30 XZ plane radiation pattern for BLE antenna initial configuration, total gain (horizontal + vertical polarisation). K100 standalone

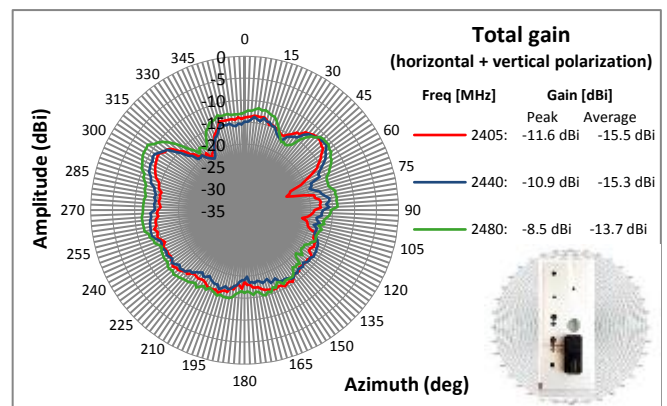


Figure 31 XZ plane radiation pattern for BLE antenna initial configuration, total gain (horizontal + vertical polarisation). K100 mounted on metal door

3.3 BLE - optimized matching

HES V3 BLE standalone

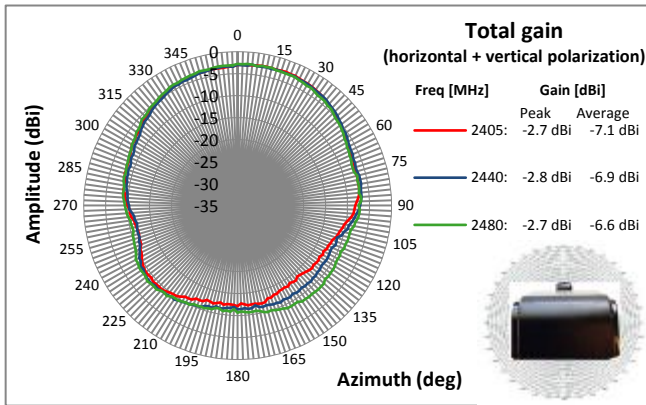


Figure 32 XY plane radiation pattern for BLE antenna with optimized matching, total gain (horizontal + vertical polarisation). K100 standalone

HES V3 BLE mounted on metal door mock-up

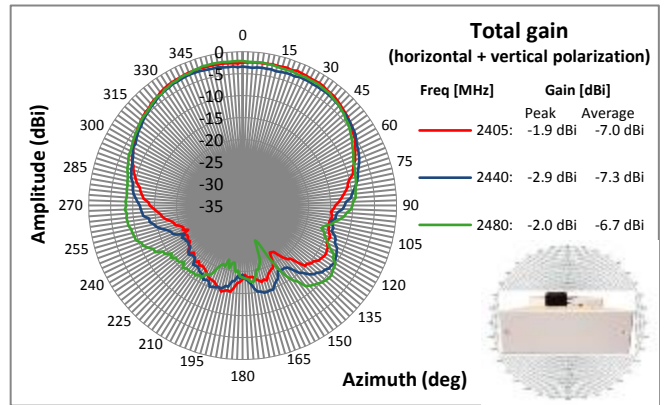


Figure 33 XY plane radiation pattern for BLE antenna with optimized matching, total gain (horizontal + vertical polarisation). K100 mounted on metal door

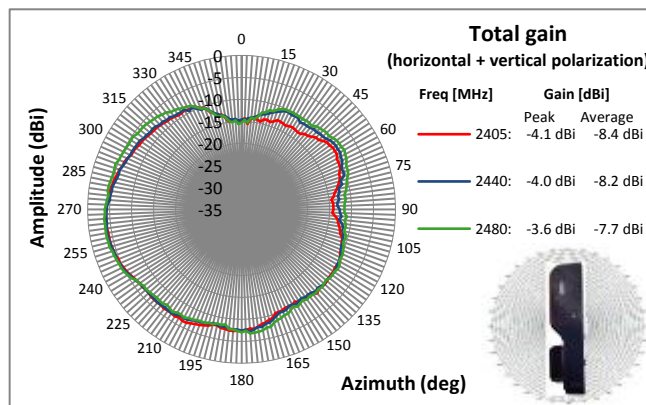


Figure 34 YZ plane radiation pattern for BLE antenna with optimized matching, total gain (horizontal + vertical polarisation). K100 standalone

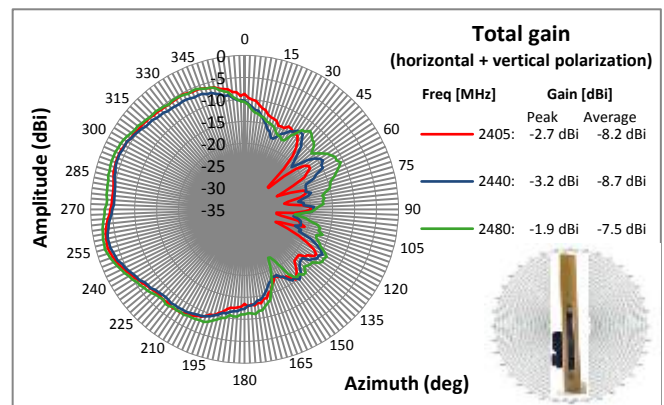


Figure 35 YZ plane radiation pattern for BLE antenna with optimized matching, total gain (horizontal + vertical polarisation). K100 mounted on metal door mock-up

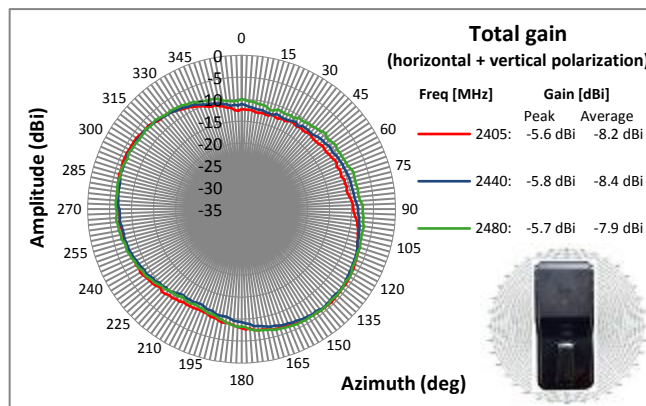


Figure 36 XZ plane radiation pattern for BLE antenna with optimized matching, total gain (horizontal + vertical polarisation). K100 standalone

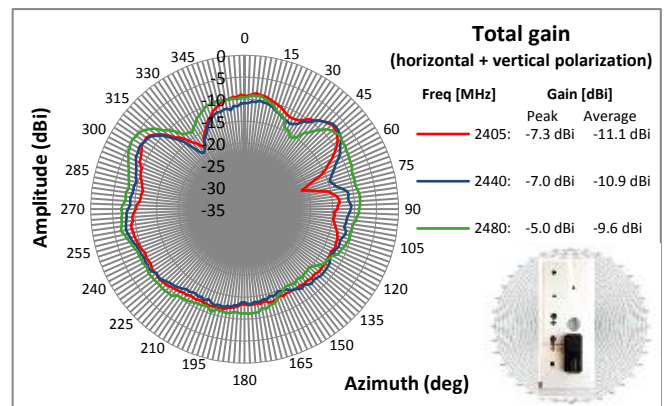
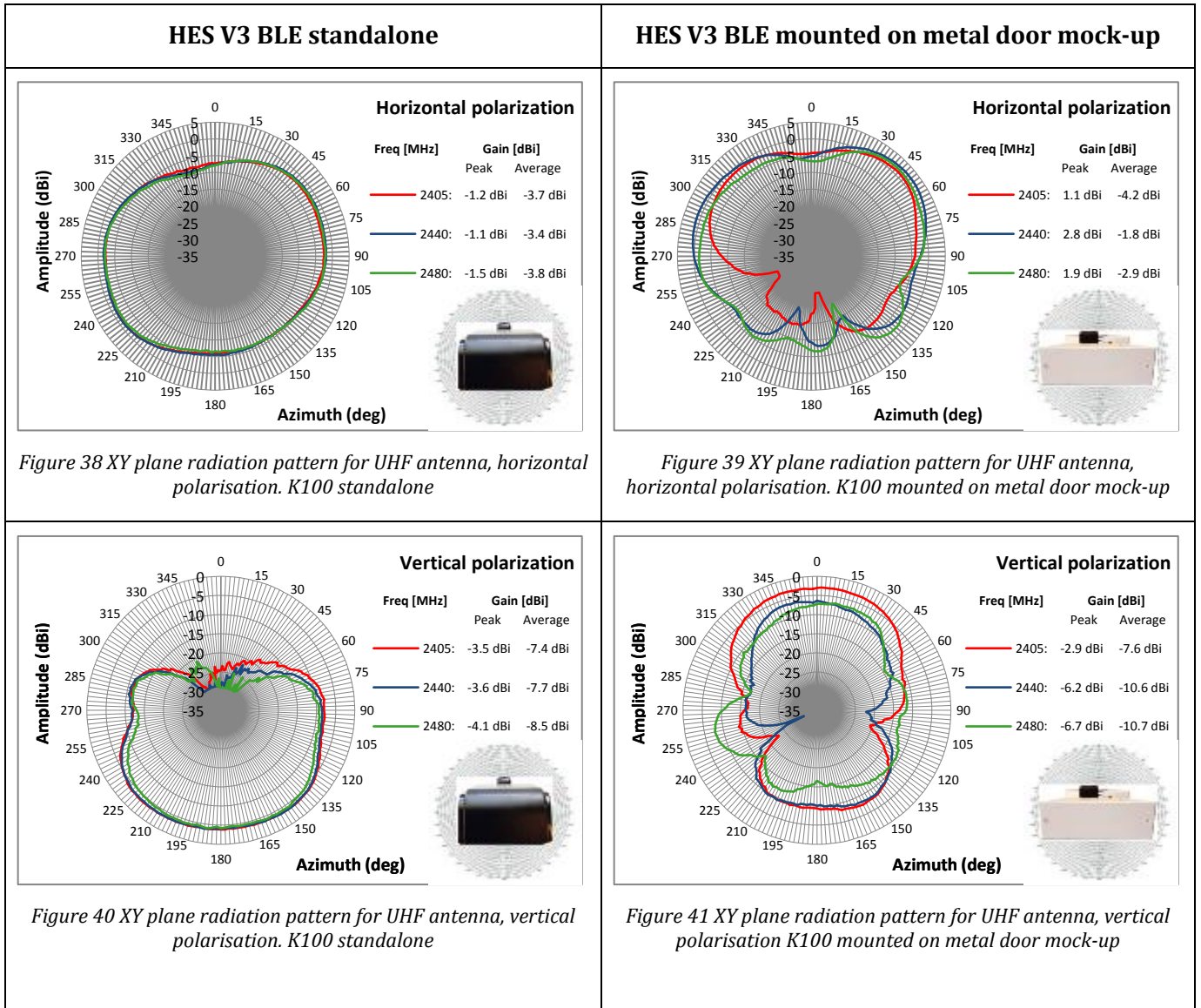


Figure 37 XZ plane radiation pattern for BLE antenna with optimized matching, total gain (horizontal + vertical polarisation). K100 mounted on metal door mock-up

A. Radiation patterns – horizontal and vertical polarization

A.1 UHF



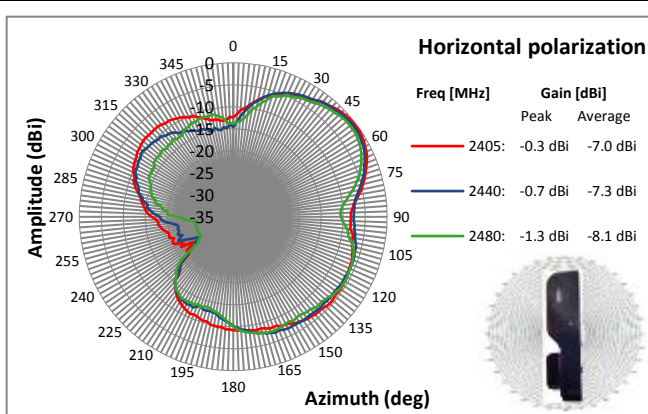


Figure 42 YZ plane radiation pattern for UHF antenna, horizontal polarisation. K100 standalone

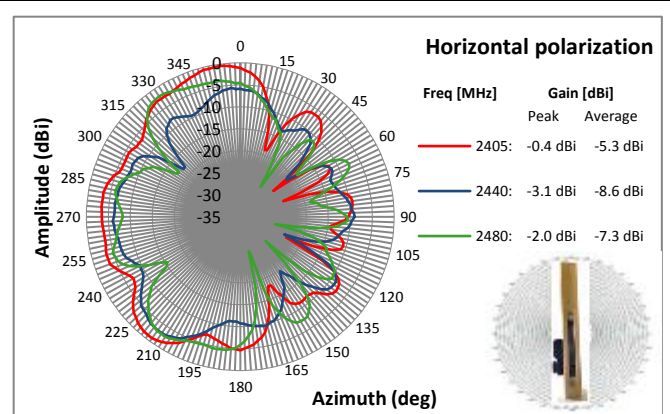


Figure 43 YZ plane radiation pattern for UHF antenna, horizontal polarisation. K100 mounted on metal door mock-up

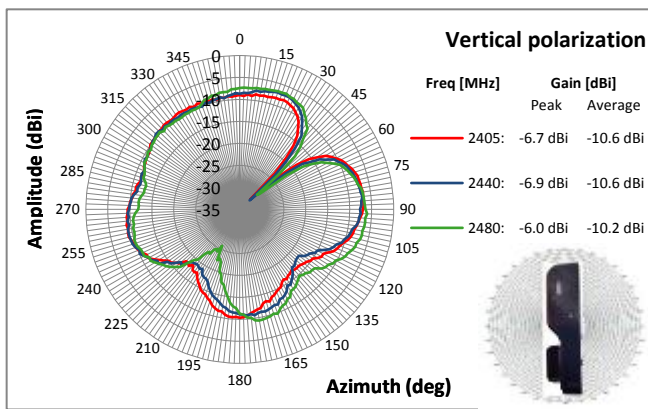


Figure 44 YZ plane radiation pattern for UHF antenna, vertical polarisation K100 standalone

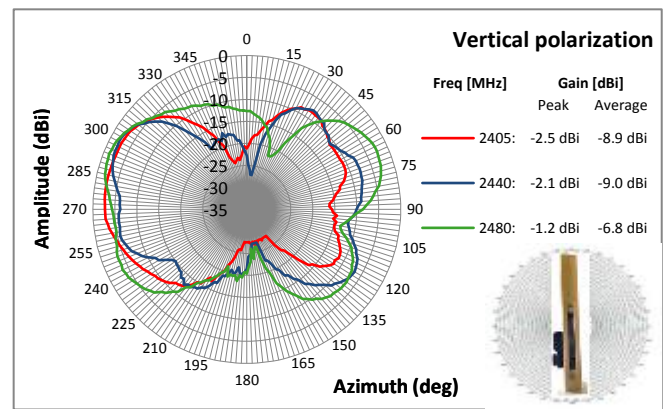


Figure 45 YZ plane radiation pattern for UHF antenna, vertical polarisation K100 mounted on metal door mock-up

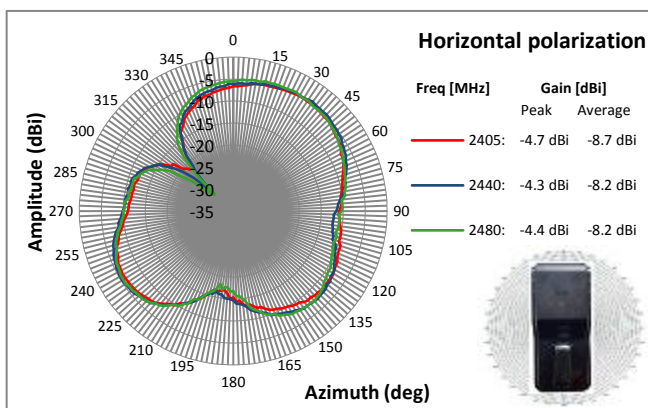


Figure 46 XZ plane radiation pattern for UHF antenna, horizontal polarisation. K100 standalone

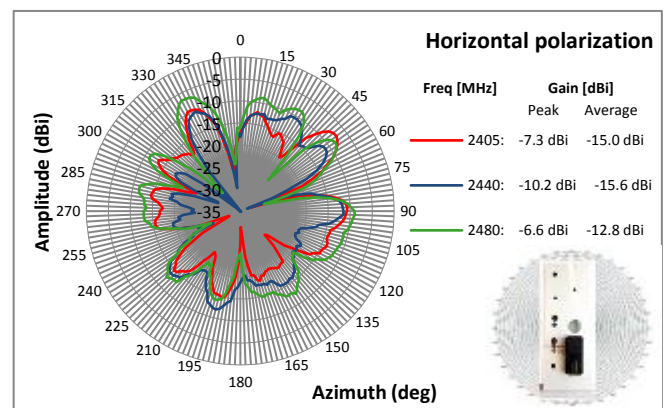


Figure 47 XZ plane radiation pattern for UHF antenna, horizontal polarisation. K100 mounted on metal door mock-up

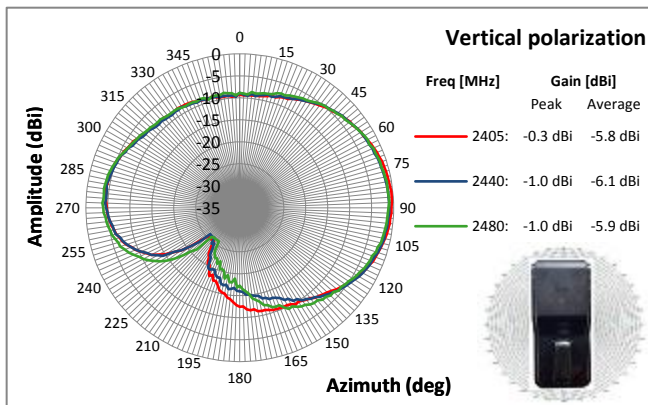


Figure 48 XZ plane radiation pattern for UHF antenna, vertical polarisation). K100 standalone

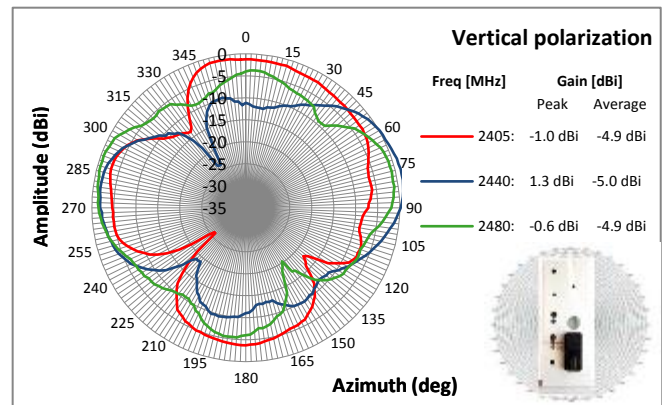


Figure 49 XZ plane radiation pattern for UHF antenna, vertical polarisation). K100 mounted on metal door mock-up

A.2 BLE – initial configuration

HES V3 BLE standalone

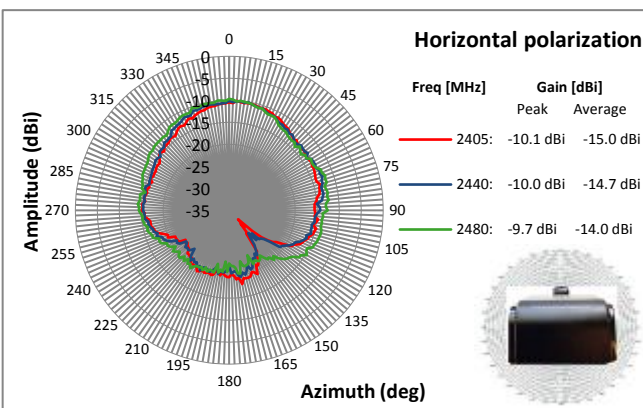


Figure 50 XY plane radiation pattern for BLE antenna initial configuration, horizontal polarisation. K100 standalone

HES V3 BLE mounted on metal door mock-up

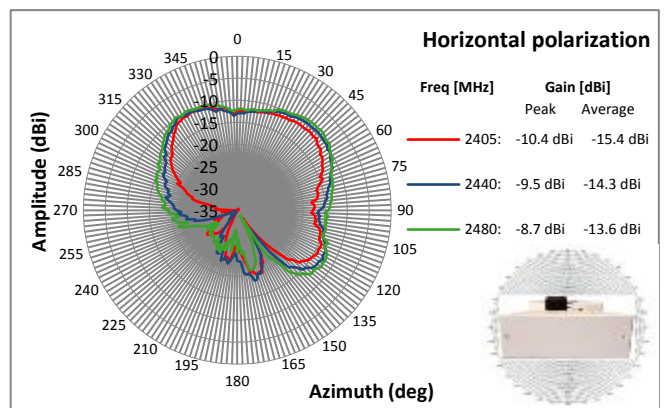


Figure 51 XY plane radiation pattern for BLE antenna initial configuration, horizontal polarisation. K100 mounted on metal door mock-up

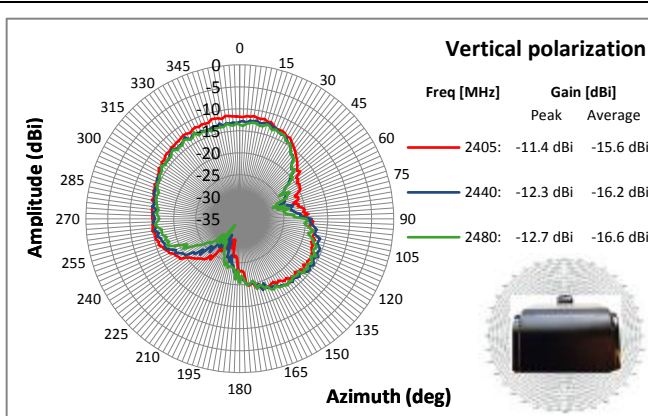


Figure 52 XY plane radiation pattern for BLE antenna initial configuration, vertical polarisation. K100 standalone

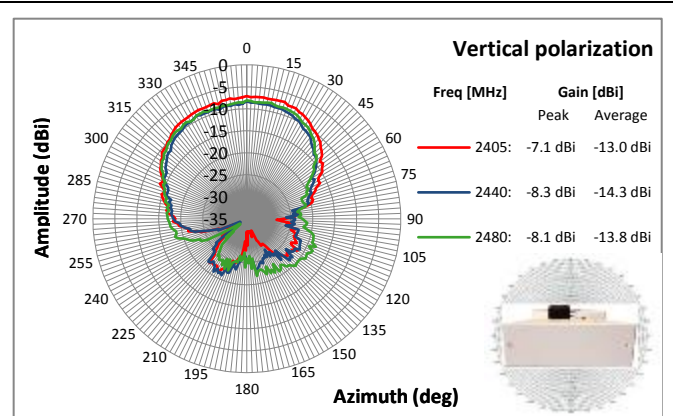


Figure 53 XY plane radiation pattern for BLE antenna initial configuration, vertical polarisation. K100 mounted on metal door mock-up

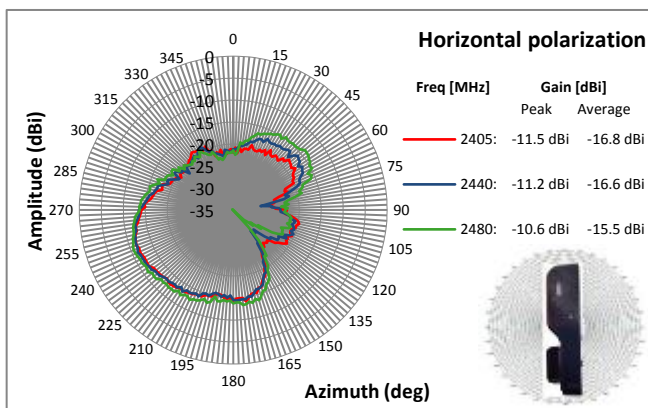


Figure 54 YZ plane radiation pattern for BLE antenna initial configuration, horizontal polarisation. K100 standalone

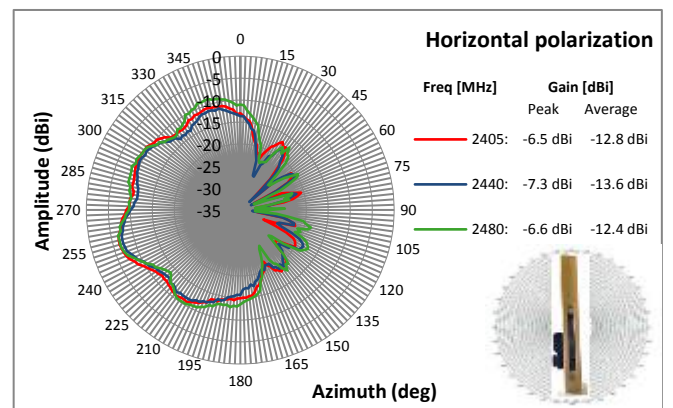


Figure 55 YZ plane radiation pattern for BLE antenna initial configuration, horizontal polarisation. K100 mounted on metal door mock-up

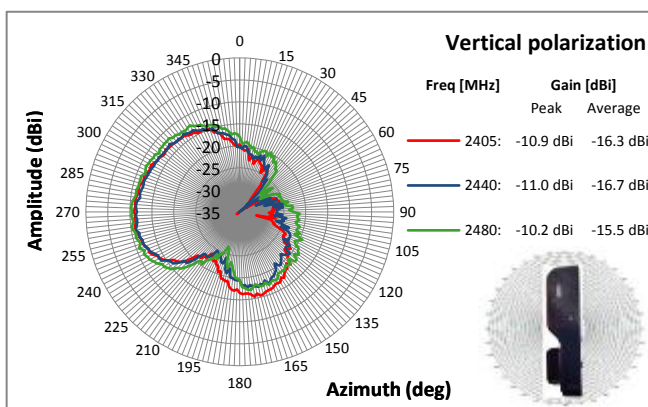


Figure 56 YZ plane radiation pattern for BLE antenna initial configuration, vertical polarisation. K100 standalone

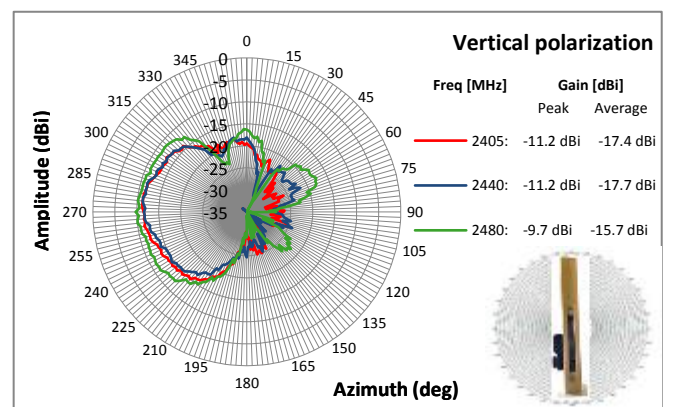


Figure 57 YZ plane radiation pattern for BLE antenna initial configuration, vertical polarisation. K100 mounted on metal door mock-up

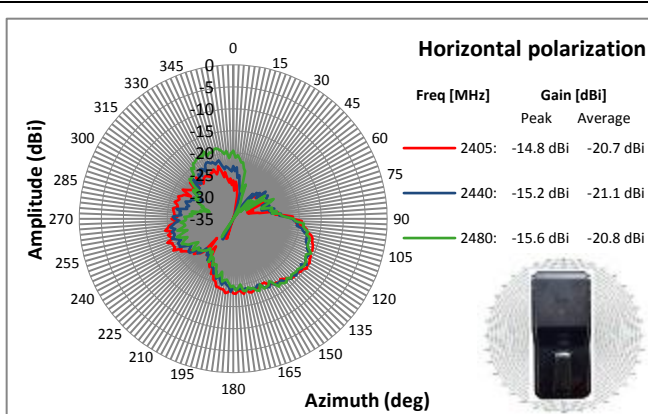


Figure 58 XZ plane radiation pattern for BLE antenna initial configuration, horizontal polarisation. K100 standalone

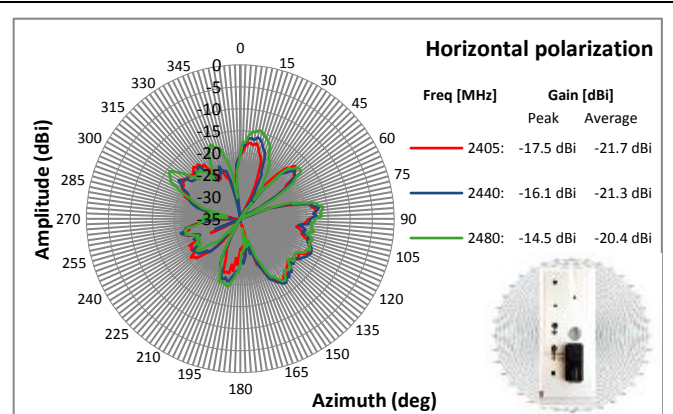


Figure 59 XZ plane radiation pattern for BLE antenna initial configuration, horizontal polarisation. K100 mounted on metal door mock-up

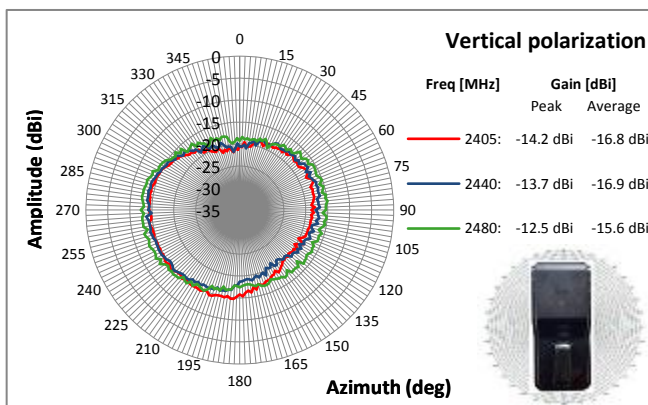


Figure 60 XZ plane radiation pattern for BLE antenna initial configuration, vertical polarisation. K100 standalone

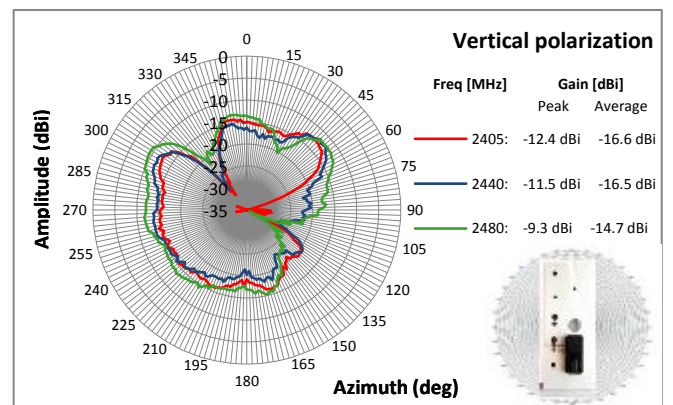
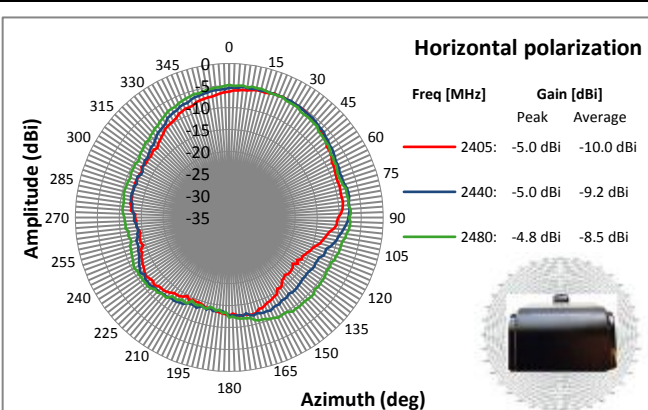


Figure 61 XZ plane radiation pattern for BLE antenna initial configuration, vertical polarisation. K100 mounted on metal door mock-up

A.3 BLE – optimized antenna matching

HES V3 BLE standalone



HES V3 BLE mounted on metal door mock-up

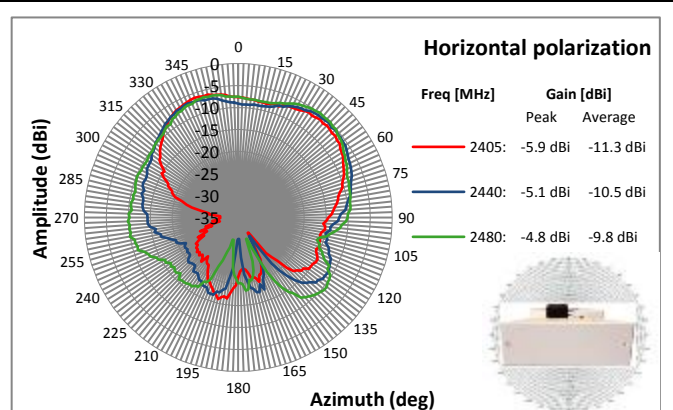


Figure 62 XY plane radiation pattern for BLE antenna with optimized matching, horizontal polarisation. K100 standalone

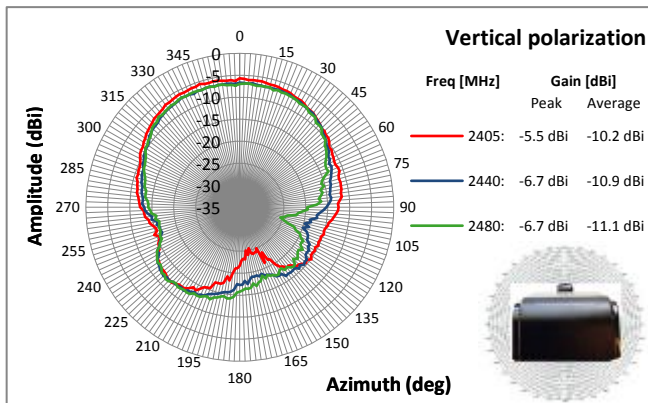


Figure 64 XY plane radiation pattern for BLE antenna with optimized matching, vertical polarisation. K100 standalone

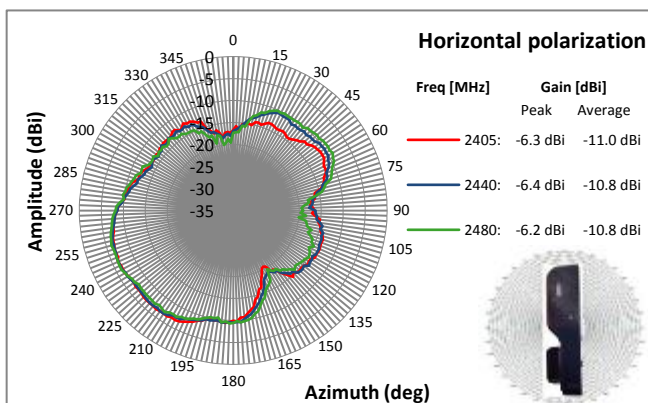


Figure 66 YZ plane radiation pattern for BLE antenna with optimized matching, horizontal polarisation. K100 standalone

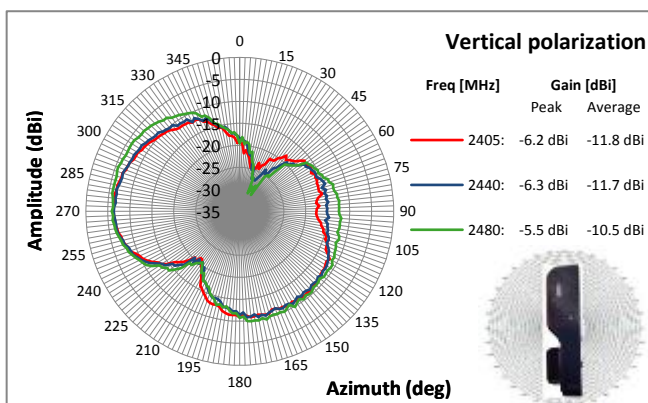


Figure 68 YZ plane radiation pattern for BLE antenna with optimized matching, vertical polarisation. K100 standalone



Figure 63 XY plane radiation pattern for BLE antenna with optimized matching, horizontal polarisation. K100 mounted on metal door mock-up

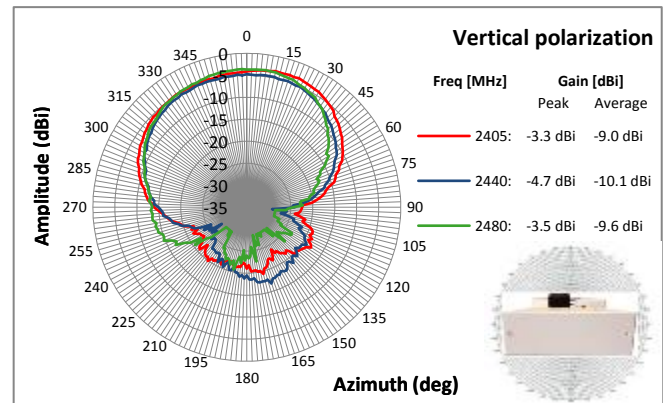


Figure 65 XY plane radiation pattern for BLE antenna with optimized matching, vertical polarisation. K100 mounted on metal door mock-up

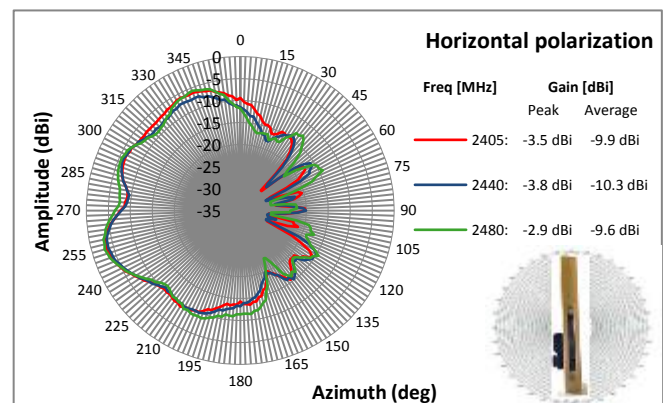


Figure 67 YZ plane radiation pattern for BLE antenna with optimized matching, horizontal polarisation. K100 mounted on metal door mock-up

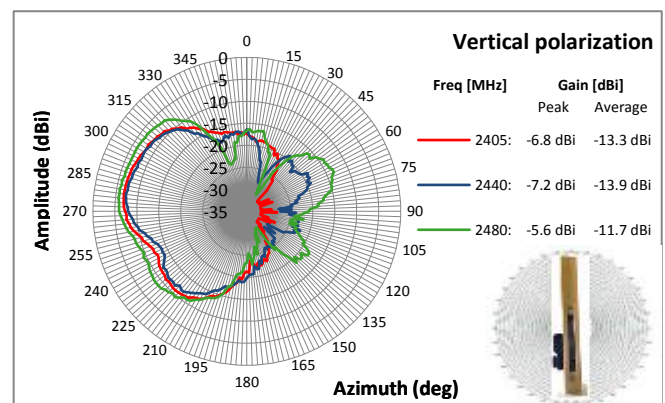


Figure 69 YZ plane radiation pattern for BLE antenna with optimized matching, vertical polarisation. K100 mounted on metal door mock-up



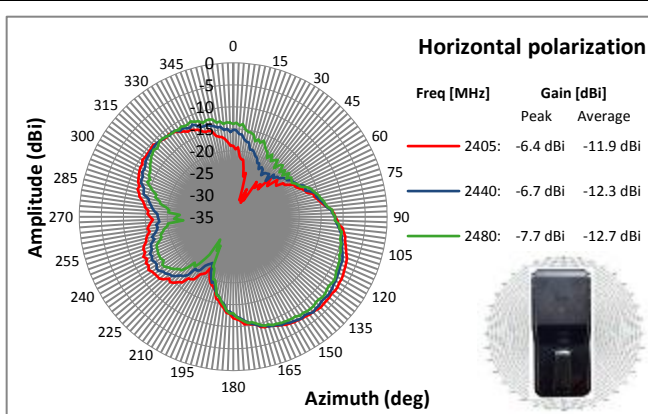


Figure 70 XZ plane radiation pattern for BLE antenna with optimized matching, horizontal polarisation. K100 standalone

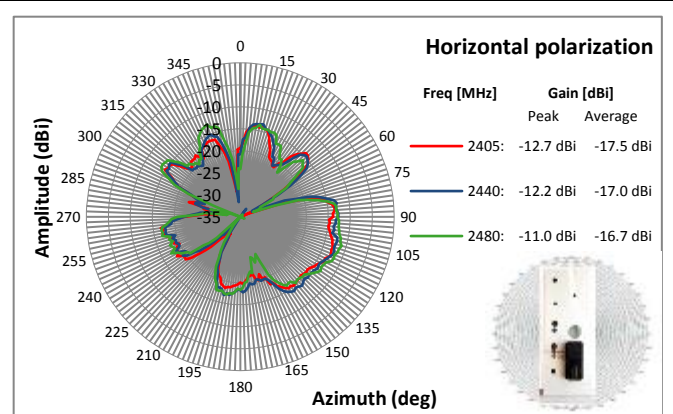


Figure 71 XZ plane radiation pattern for BLE antenna with optimized matching, horizontal polarisation. K100 mounted on metal door mock-up

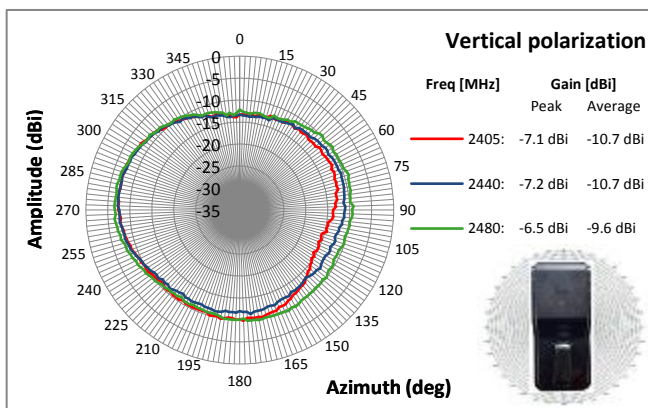


Figure 72 XZ plane radiation pattern for BLE antenna with optimized matching, vertical polarisation. K100 standalone

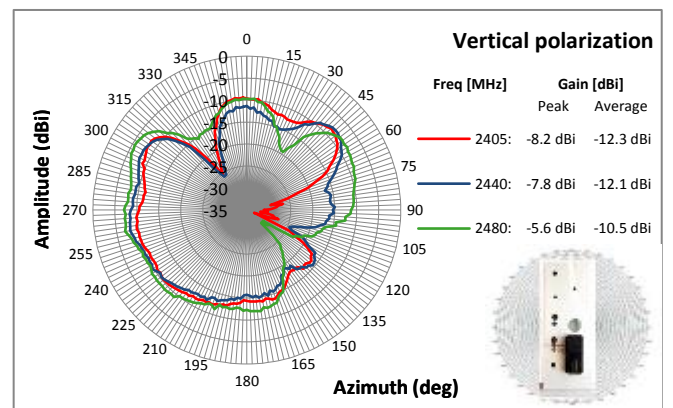


Figure 73 XZ plane radiation pattern for BLE antenna with optimized matching, vertical polarisation. K100 mounted on metal door mock-up