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Test report no.:

240001-AU01+W02

for:

Robert Bosch Power Tools GmbH
BTLE smart plug
GCA 30-42

Location of Testing:

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1 Summary of test results

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Antenna gain above 1 GHz	18
Antenna pattern above 1 GHz	21

Table 1: Test result

Straubing, January 26, 2024



Tested by
Konrad Graßl
Department Manager Radio



Approved by
Christian Kiermeier
Reviewer

2 Equipment under test (EUT)

All information in this clause is declared by manufacturer.

2.1 General information

Product type:	BTLE smart plug
Model name:	GCA 30-42
Part number:	1600A02GE4 (EU)
Serial number:	n/a
Manufacturer:	Robert Bosch Power Tools GmbH
Short description:	The EUT is a BTLE smart plug (GCA 30-42) used for worksite vacuum cleaners. It is receiving the activation signal of a BTLE smart tag (GCT 30-42) in the 2.4 GHz range to start the dust extrusion.

Notes:

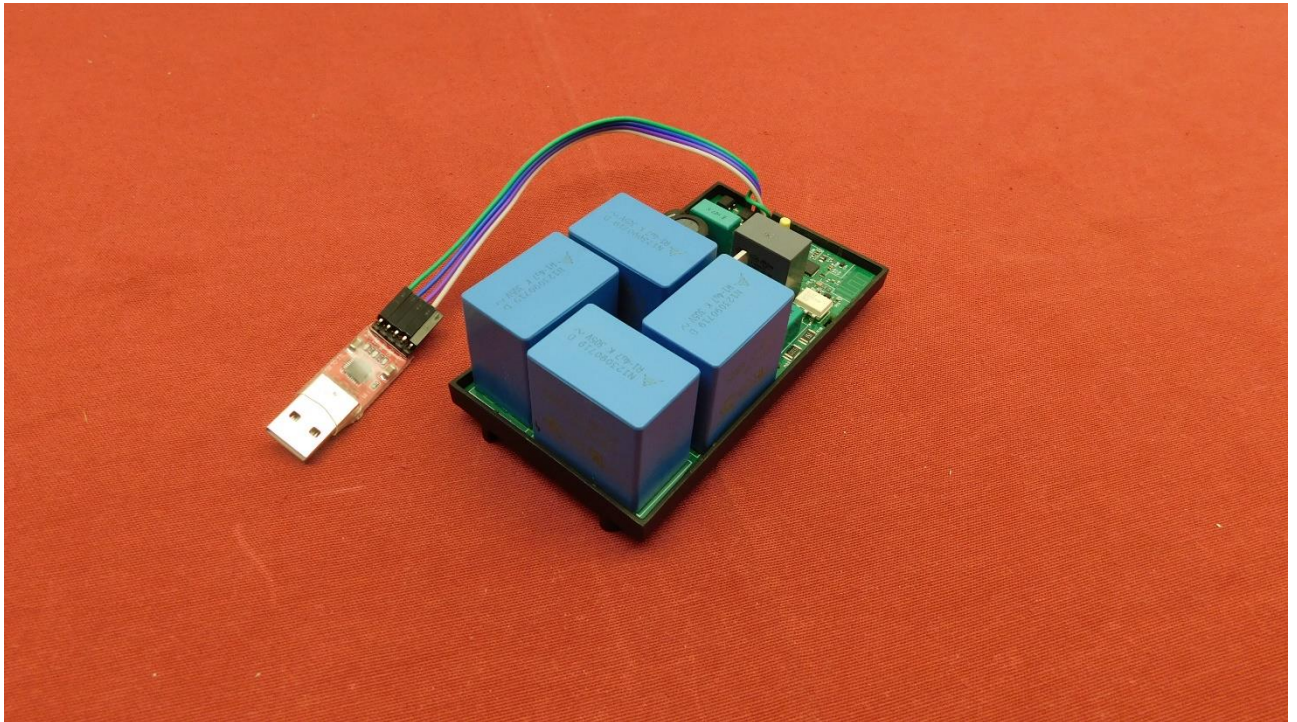
1. According to customer's declaration, all models (part numbers) mentioned below are identical with the tested EUT and only differ in the printing label.
2. All tests documented in this test report were performed with GCA 30-42.

<i>Model name</i>	<i>Part number</i>
GCA 30-42	1600A02GE4 (EU)
GCA 30-42	1600A02GE5 (UK)
GCA 30-42	1600A02GE6 (UK)
GCA 30-42	1600A02GE7 (CH)
GCA 30-42	1600A02GE8 (AU/NZS)
GCA 30-42	1600A02GE9 (JP)
GCA 30-42	1600A02GH6 (KR)
GCA30-42	1600A02GF0 (RNA)

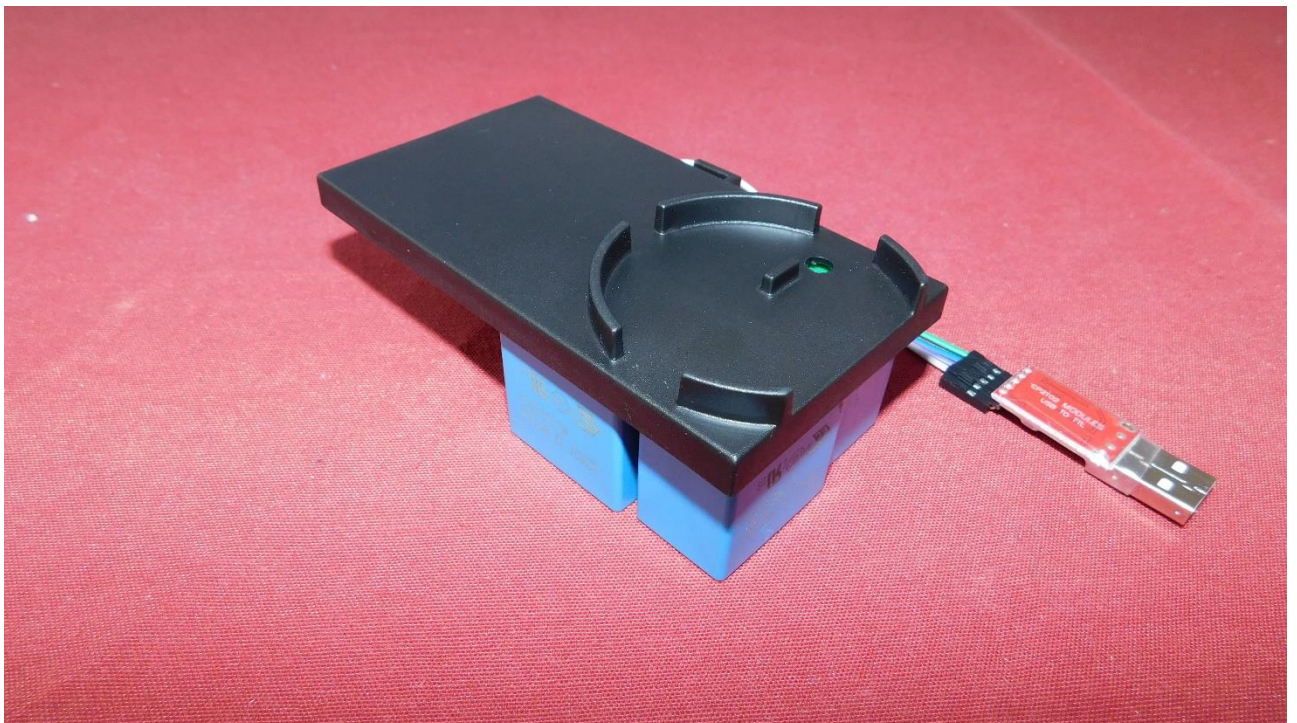
2.2 Radio specifications

Application(s):	Wideband data transmission system		
Operational frequency band(s):	2.4 GHz		
Tested frequencies:	2402 MHz, 2440 MHz, 2480 MHz		
Number of transmit chains:	1		
Antenna:	Type:	PCB antenna	
	Connector:	<input type="checkbox"/> external	<input type="checkbox"/> internal
		<input type="checkbox"/> temporary	<input checked="" type="checkbox"/> none (integral antenna)

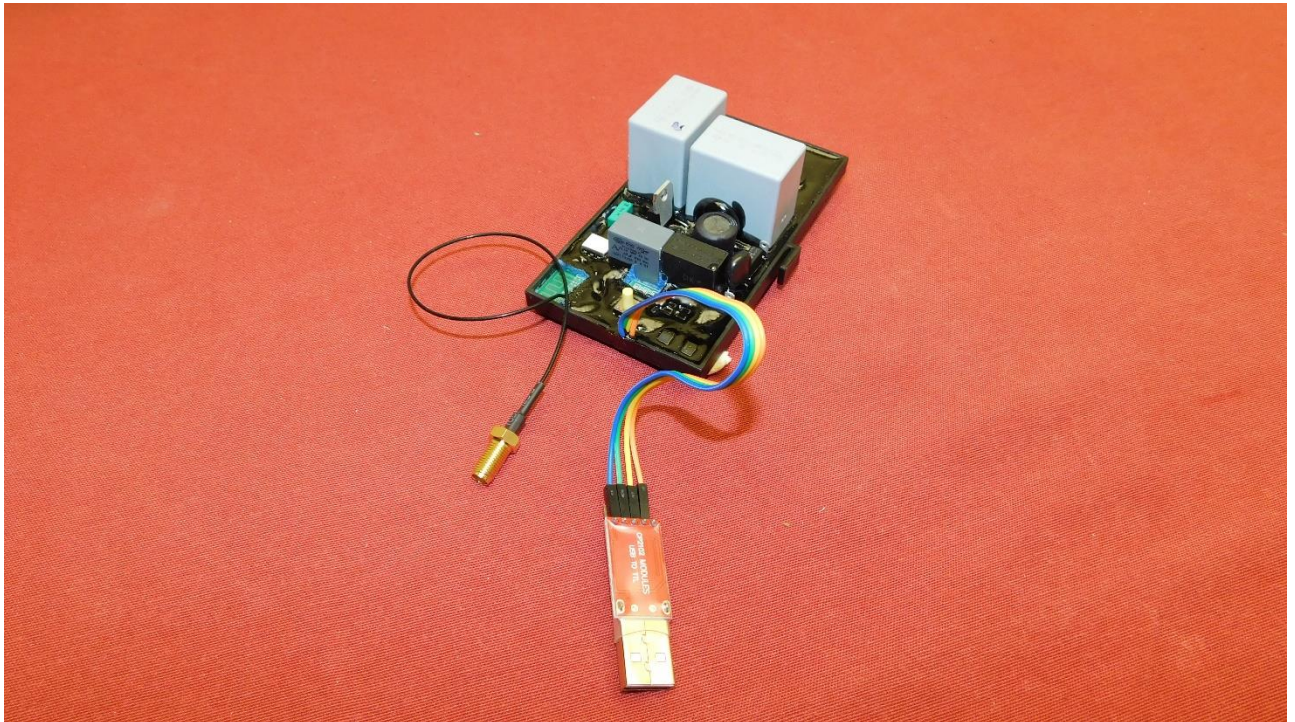
3 Photographs of EUT



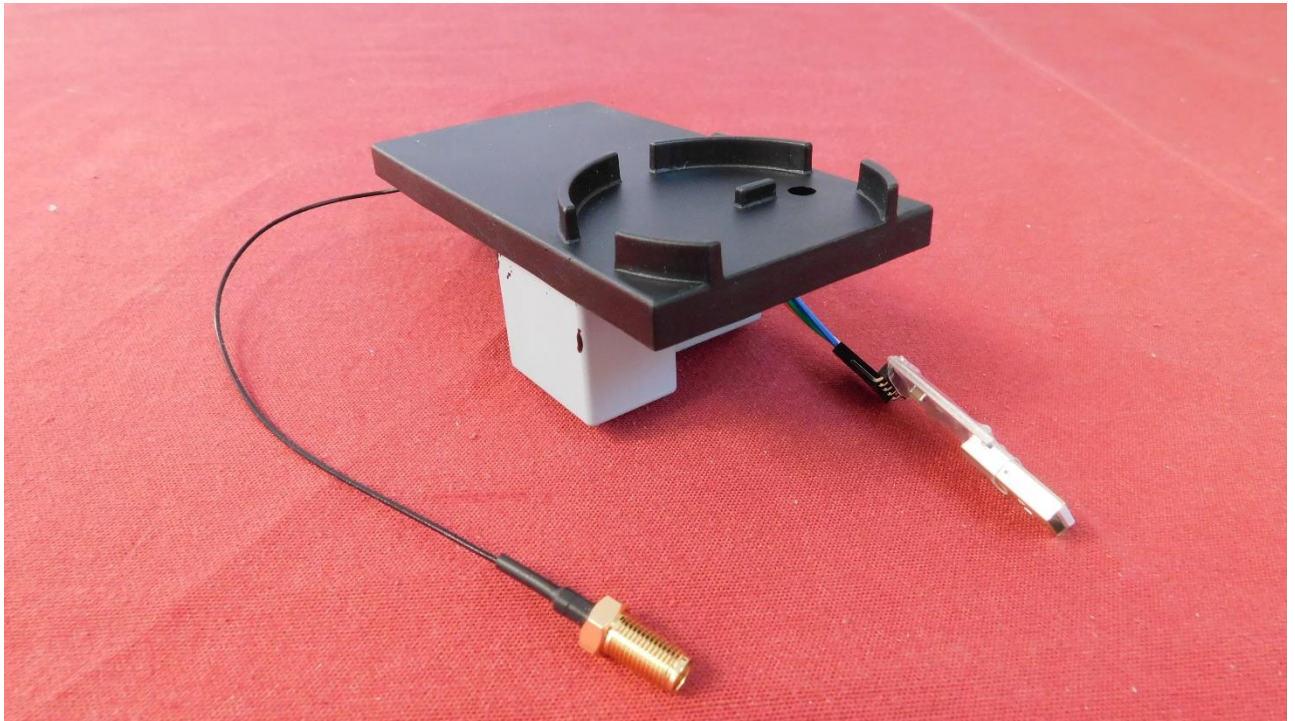
Picture 1: Top view of EUT for radiated tests



Picture 2: Back view of EUT for radiated tests



Picture 3: Top view of EUT for conducted tests



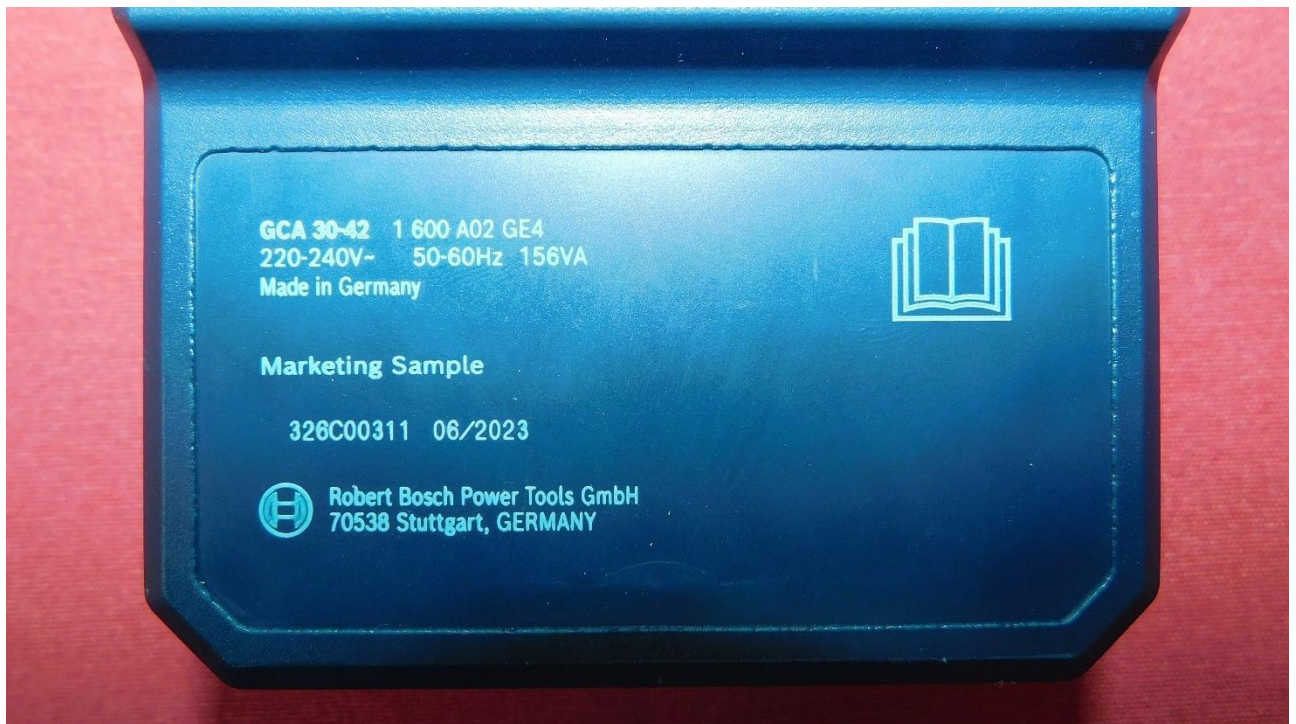
Picture 4: Back view of EUT for conducted tests



Picture 5: Front view of final device



Picture 6: Back view of final device



Picture 7: Name plate of EUT

4 Test configuration and mode of operation

4.1 Test configuration

<i>Device</i>	<i>Type designation</i>	<i>Serial or inventory no.</i>	<i>Manufacturer</i>
BTLE smart plug	GCA 30-42 (sample for radiated tests)	n/a	Robert Bosch Power Tools GmbH
BTLE smart plug	GCA 30-42 (sample for conducted tests)	n/a	Robert Bosch Power Tools GmbH

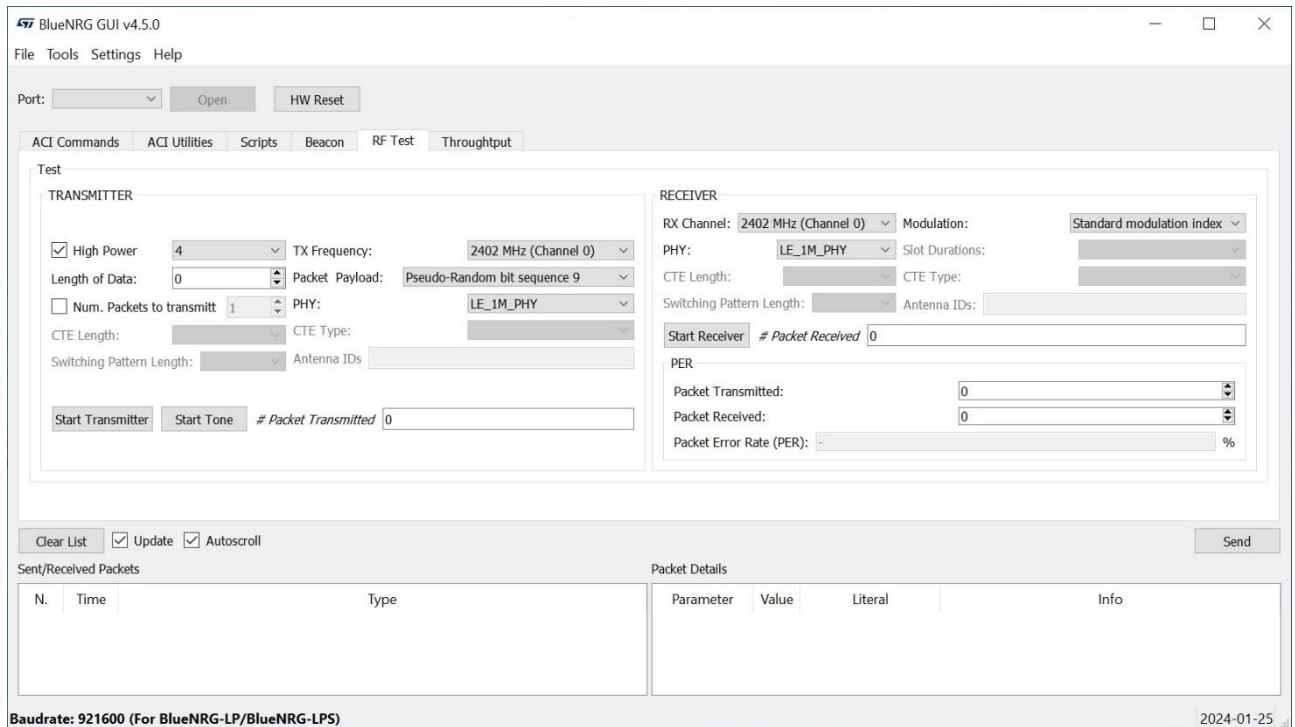
Table 2: EUT used for testing

<i>Device</i>	<i>Type designation</i>	<i>Serial or inventory no.</i>	<i>Manufacturer</i>
Laptop	ProBook 440 G6	5CD941CVQY	HP
Power supply for laptop	AC adapter	L25296-002	HP

Table 3: Support equipment used for testing

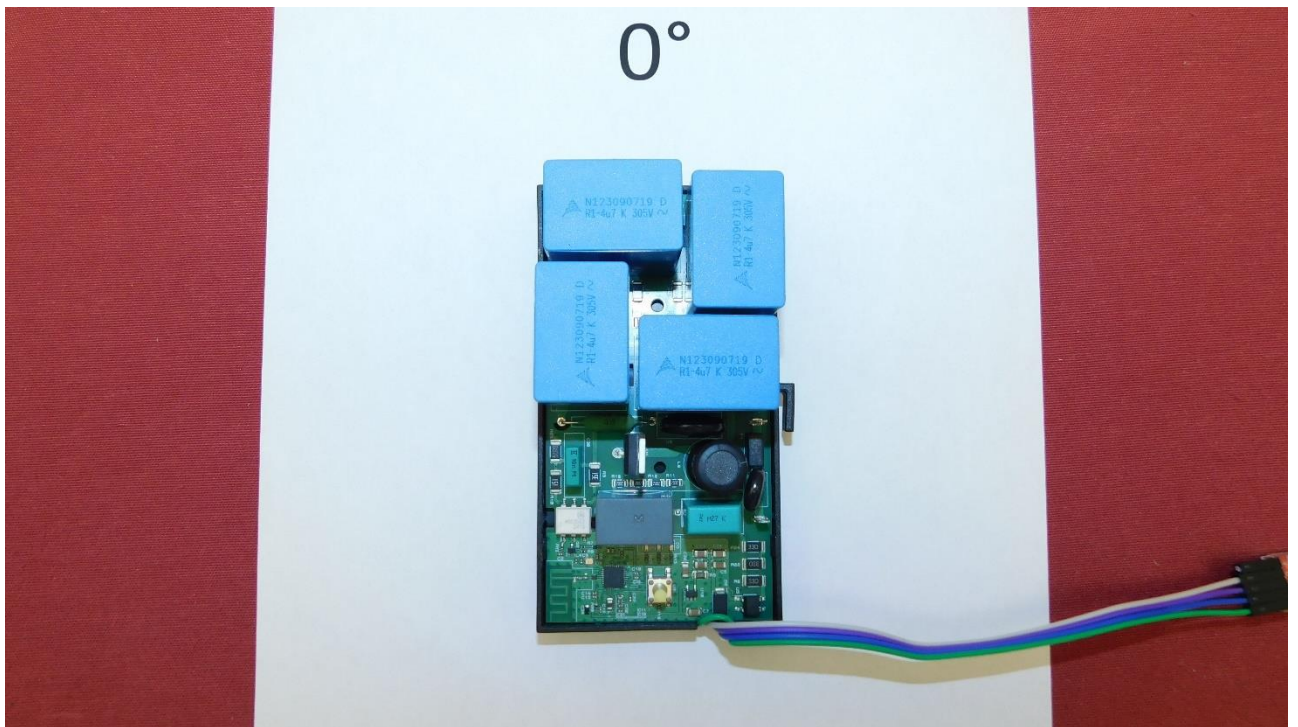
4.2 Mode of operation

- The EUT was continuously transmitting an unmodulated signal at 2402 MHz, 2440 MHz or 2480 MHz.
- The EUT was connected to a laptop and powered via USB.
- The test software BlueNRG GUI was used to set the EUT in the appropriate test modes.
- Power setting in the test software: enable High Power option with value 4

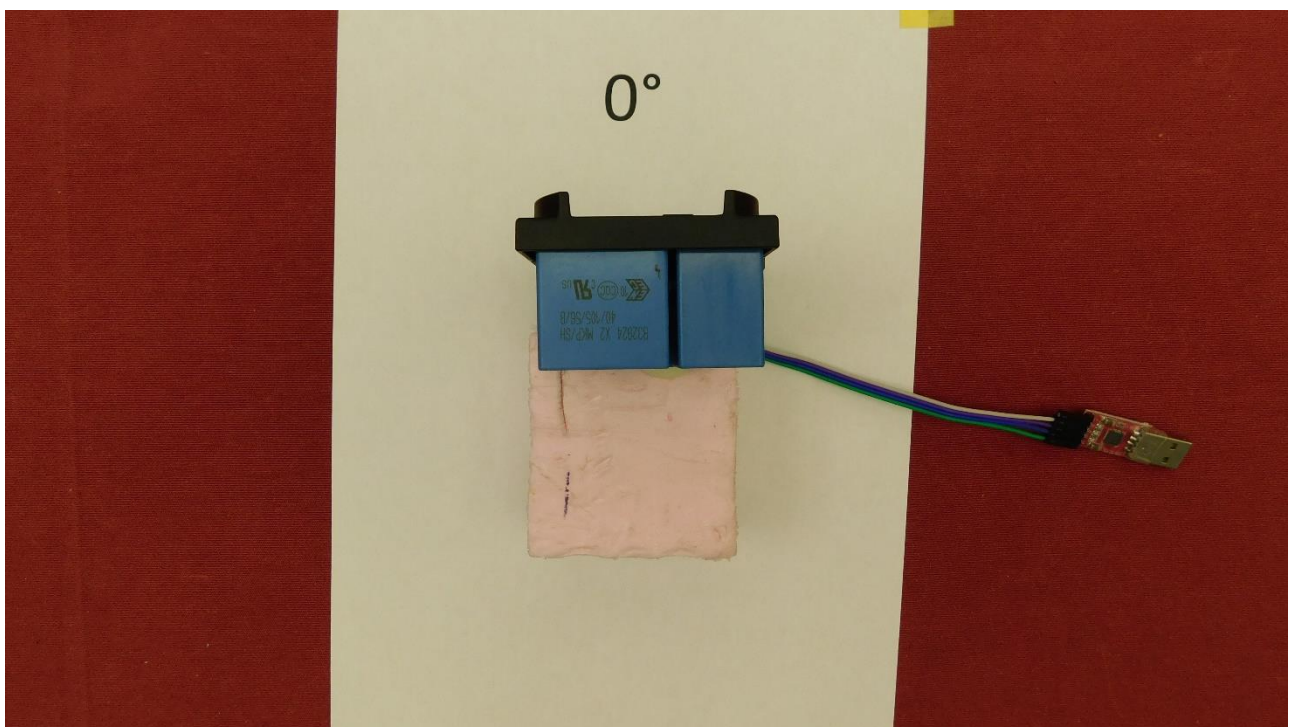


Picture 8: Screenshot of the test software settings

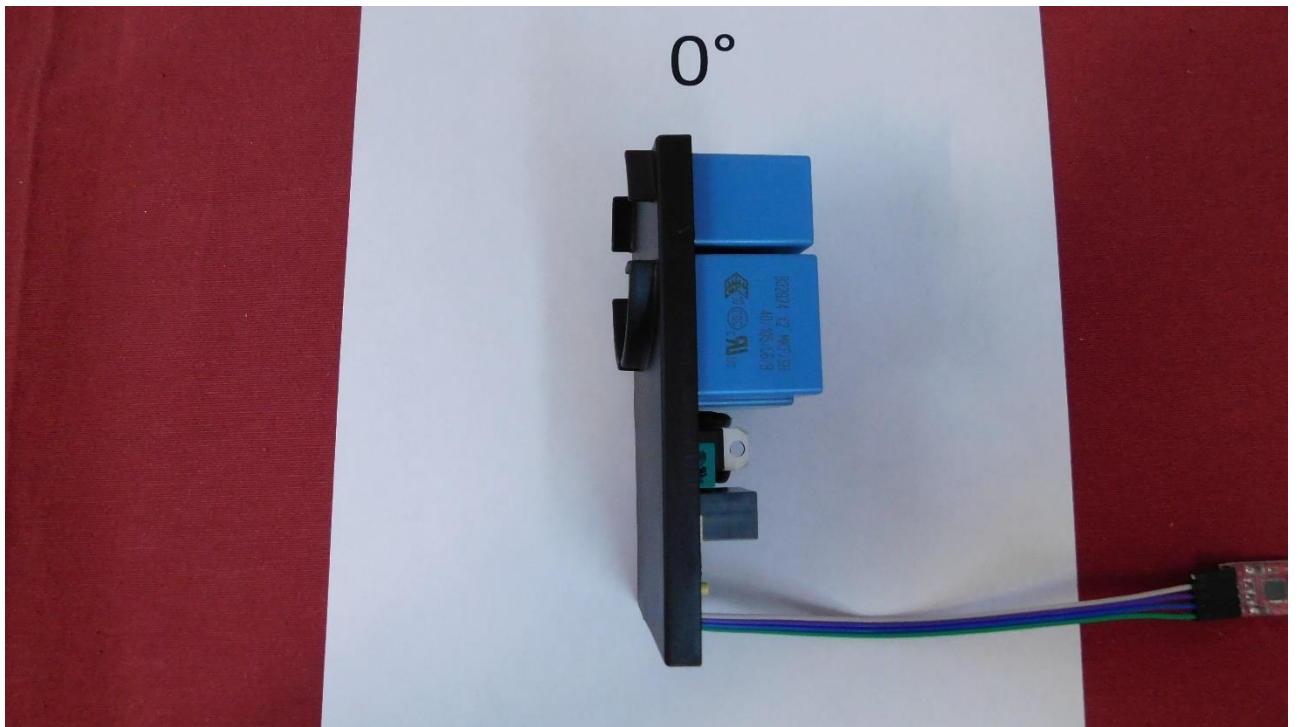
4.3 EUT positions



Picture 9: Setup for EUT position X



Picture 10: Setup for EUT position Y



Picture 11: Setup for EUT position Z

5 Measurement procedures

5.1 Conducted measurements at antenna connector

The RF signal of the EUT is measured at the external or internal antenna connector. In case of no permanent antenna connector, a temporary antenna connector needs to be supplied by the manufacturer. The specific insertion loss of the signal path, which is matched to 50 Ohm, is evaluated within a calibration. The test receiver is set to analyser mode with pre-selector activated. All measurement readings are corrected by the signal path loss.

The power of the carrier frequency is measured.

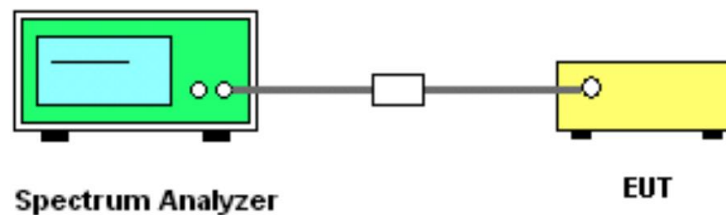


Figure 1: Setup for conducted measurements at antenna connector

5.2 Antenna gain above 1 GHz

Radiated measurement of the antenna gain is performed in an anechoic room with floor absorbers. The measurement distance is 1.5 metres.

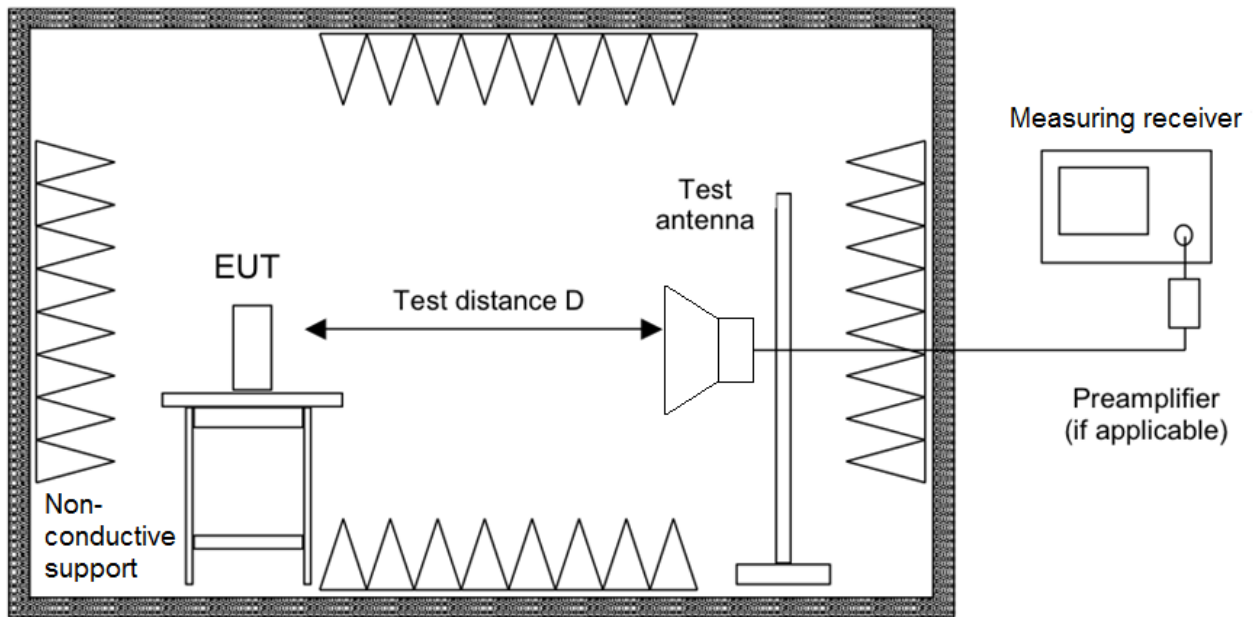
A turntable capable of rotation through 360° in the horizontal plane is used to support the EUT at as close as possible to a height of 1.5 m above the ground plane. The measurement antenna is mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization and in the same height as the EUT.

The measurement antenna is a horn antenna.

The radiated measurement of the antenna gain is performed in several steps:

- a) The EUT is placed on the support in its standard position and set to the mode of operation (see clause 4.2).
- b) The measurement antenna is oriented initially for vertical polarization unless otherwise stated.
- c) The measurement equipment is connected to the measurement antenna and set-up according to the specifications of the test.
- d) The EUT is rotated in a horizontal plane through 360°. Continuously the power of the used frequency is measured and recorded.
- e) Steps a) to d) are repeated for horizontal polarization.

If the EUT may be used in various positions, steps a) to e) are repeated in other three orthogonal positions.



Fully anechoic room or semi-anechoic chamber with floor absorbers

Figure 2: Setup for radiated measurement of antenna gain above 1 GHz

5.3 Antenna pattern above 1 GHz

Radiated measurement of the antenna pattern is performed in an anechoic room with floor absorbers. The measurement distance is 1.5 metres.

A turntable capable of rotation through 360° in the horizontal plane is used to support the EUT at as close as possible to a height of 1.5 m above the ground plane. The measurement antenna is mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization and in the same height as the EUT.

The measurement antenna is a horn antenna.

The radiated measurement of the antenna pattern is performed in several steps:

- a) The EUT is placed on the support in its standard position and set to the mode of operation (see clause 4.2).
- b) The measurement antenna is oriented initially for vertical polarization unless otherwise stated and the EUT is placed on the support in its standard position and switched on.
- c) The measurement equipment is connected to the measurement antenna and set-up according to the specifications of the test.
- d) The EUT is rotated in a horizontal plane through 360° in steps of 6°. At each step the power of the used frequency is measured and recorded.
- e) Steps a) to d) are repeated for horizontal polarization.

If the EUT may be used in various positions, steps a) to e) are repeated in other three orthogonal positions.

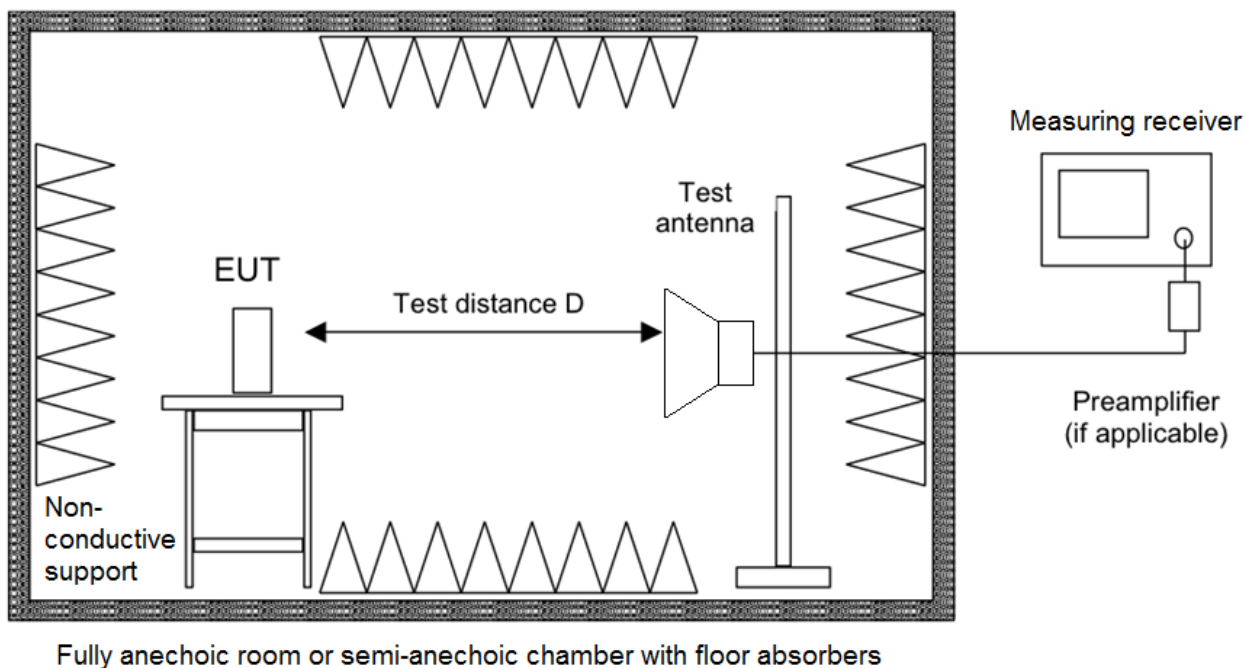


Figure 3: Setup for radiated measurement of antenna pattern above 1 GHz

6 Test results

This clause gives details about the test results as collected in the Summary of test results starting on page 5.

For information about measurement uncertainties see page **Fehler! Textmarke nicht definiert..**

The climatic conditions are recorded during the tests. It is ensured that the climatic conditions are within the following ranges:

<i>Ambient temperature</i>	<i>Ambient humidity</i>	<i>Ambient pressure</i>
15°C to 35°C	30 % to 75 %	86 kPa to 106 kPa

6.1 Antenna gain above 1 GHz

Performed by: Konrad Graßl Date(s) of test: January 24, 2024

6.1.1 Test equipment

Type	Designation	Manufacturer	Inventory no.
Free space semi-anechoic chamber (FS-SAC)	FS-SAC	ELEMENT STRAUBING	E00100
EMI test receiver	ESU 26	Rohde & Schwarz	W00002
Attenuator (20 dB)	R411.820.121	RADIALL	W00708
Preamplifier (0.5 GHz - 18 GHz)	BBV 9718 B	Schwarzbeck	W01325
Horn antenna	BBHA 9120D	Schwarzbeck	W00053
Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433

6.1.2 Measurement procedure

Antenna gain is measured using the

- conducted measurement procedure as described in clause 5.1 and
- radiated measurement procedure as described in clause 5.2.

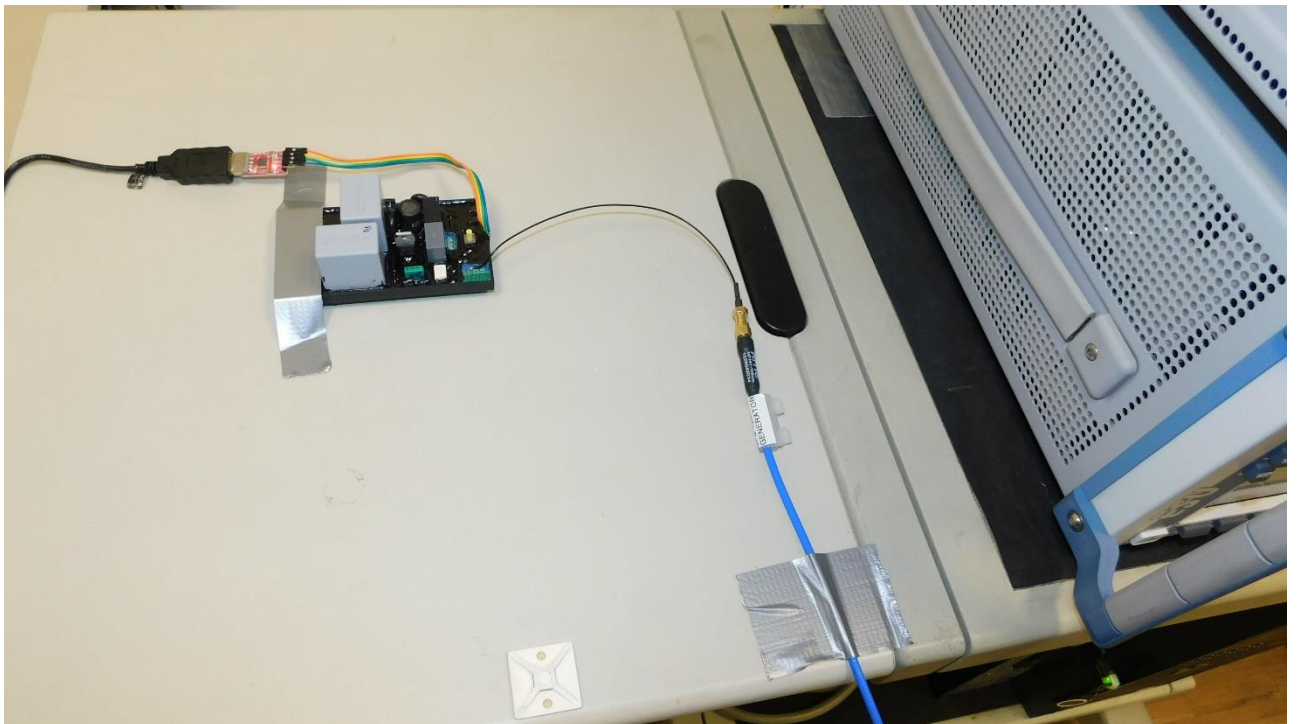
Note(s):

1. The field strength was measured at a measurement distance of 1.5 m.
2. EIRP was calculated as defined in clause 9.5 of ANSI C63.10-2013.
3. Conducted output power is calculated by subtracting the gain of the EIRP.

6.1.3 Test setup



Picture 12: Setup for radiated measurement



Picture 13: Setup for conducted measurement

6.1.4 Test results

Note(s):

- 1 Premeasurements were performed to declare the worst case which is documented below.
- 2 The highest EIRP was measured in position Y with the antenna in horizontal polarization.
- 3 The gain is calculated with the following formula:

$$\text{Calculated antenna gain} = \text{E.I.R.P.} - \text{conducted power}$$

<i>Frequency (MHz)</i>	<i>EIRP (dBm)</i>	<i>Conducted power (dBm)</i>	<i>Calculated antenna gain (dBi)</i>
2402	-2.3	-2.8	0.5
2440	-1.6	-2.8	1.2
2480	-0.3	-2.7	2.4

Table 4: Final result of antenna gain

6.2 Antenna pattern above 1 GHz

Performed by: Konrad Graßl Date(s) of test: January 16, 2024

6.2.1 Test equipment

Type	Designation	Manufacturer	Inventory no.
Free space semi-anechoic chamber (FS-SAC)	FS-SAC	ELEMENT STRAUBING	E00100
EMI test receiver	ESU 26	Rohde & Schwarz	W00002
Attenuator (20 dB)	R411.820.121	RADIALL	W00708
Preamplifier (0.5 GHz - 18 GHz)	BBV 9718 B	Schwarzbeck	W01325
Horn antenna	BBHA 9120D	Schwarzbeck	W00053
Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433

6.2.2 Measurement procedure

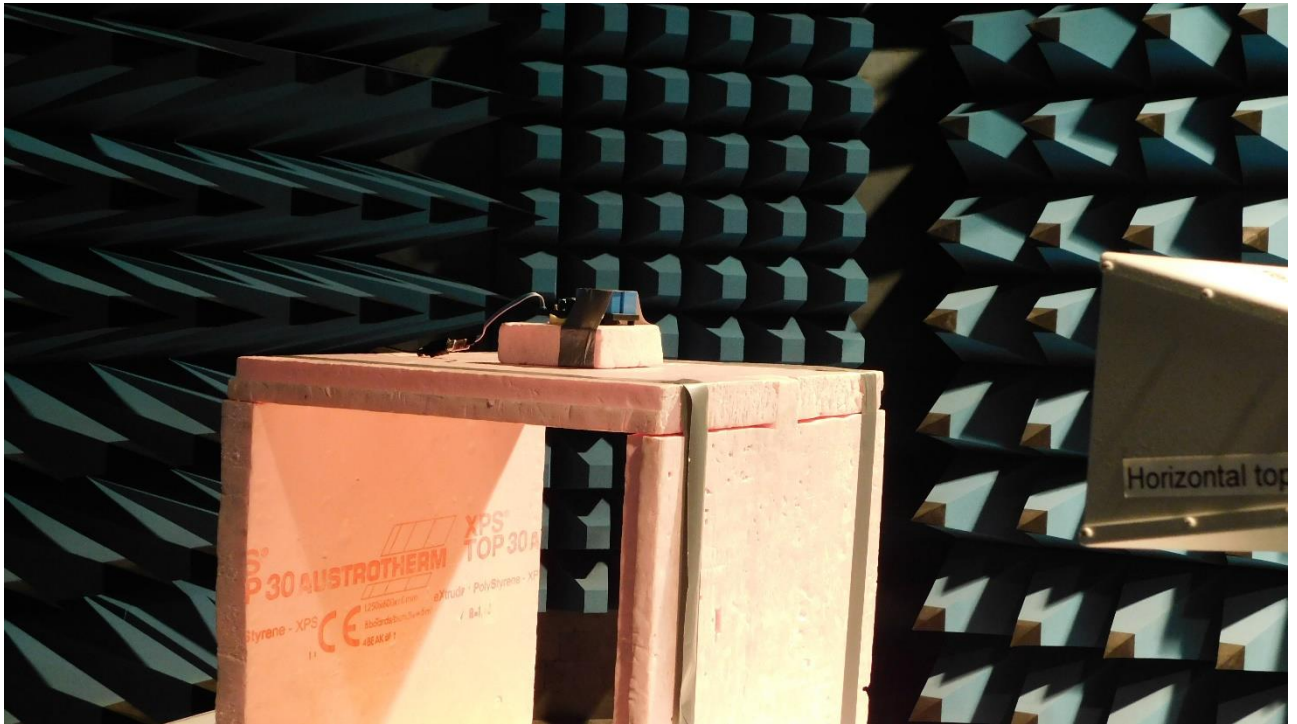
Antenna pattern is measured using the

- radiated measurement procedure as described in clause 5.3.

Note(s):

1. The field strength was measured at a measurement distance of 1.5 m.
2. EIRP was calculated as defined in clause 9.5 of ANSI C63.10-2013.
3. Conducted output power is calculated by subtracting the gain of the EIRP.

6.2.3 Test setup



Picture 14: Setup for measuring the antenna pattern

6.2.4 Test results

General note(s):

- 1 The black line shows the EIRP.
- 2 The red line shows the value which is 3 dB lower than the highest EIRP.

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -2.6 dBm.

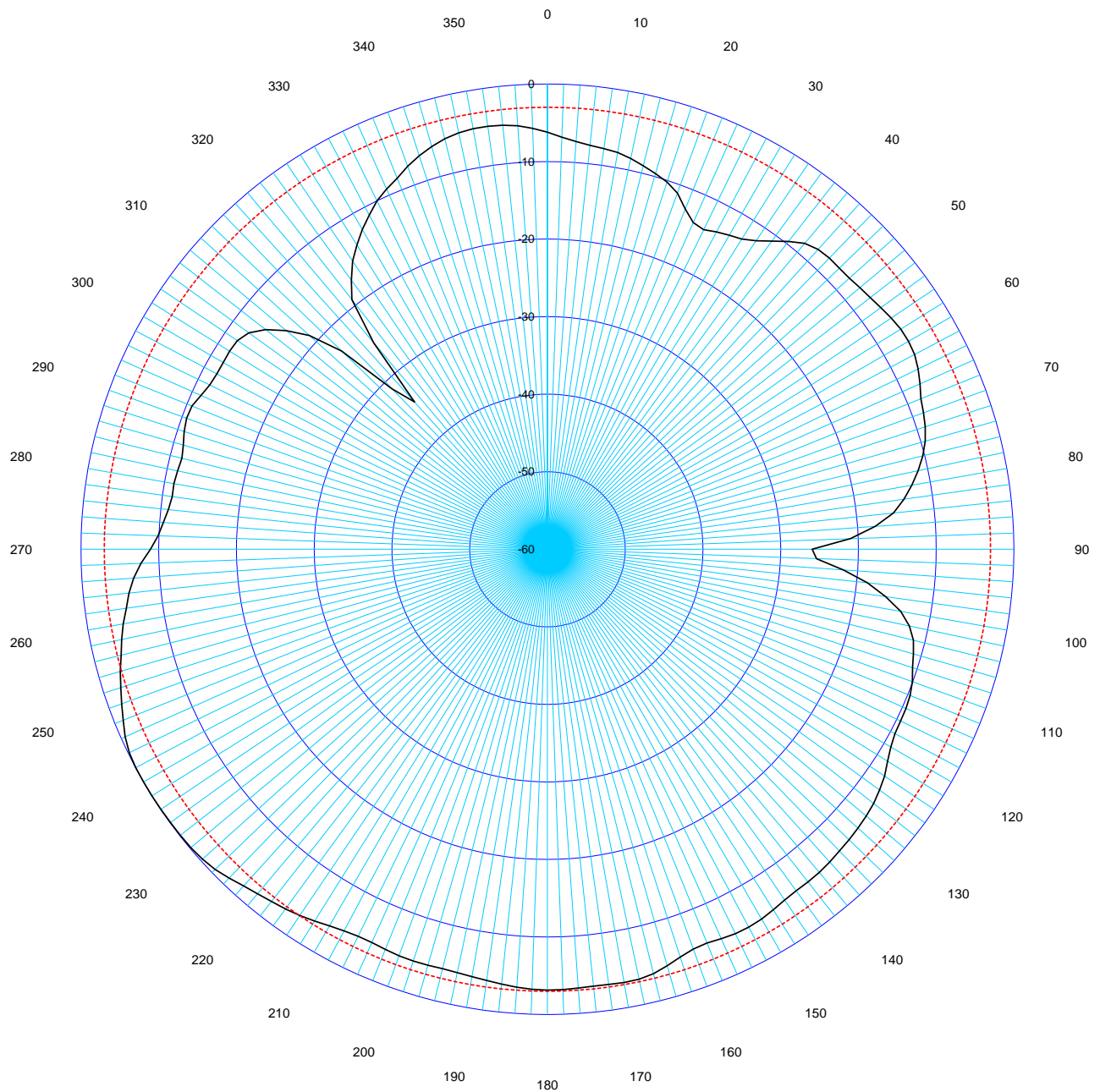


Figure 4: Antenna pattern of 2402 MHz in EUT position X and horizontal polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -12.2 dBm.

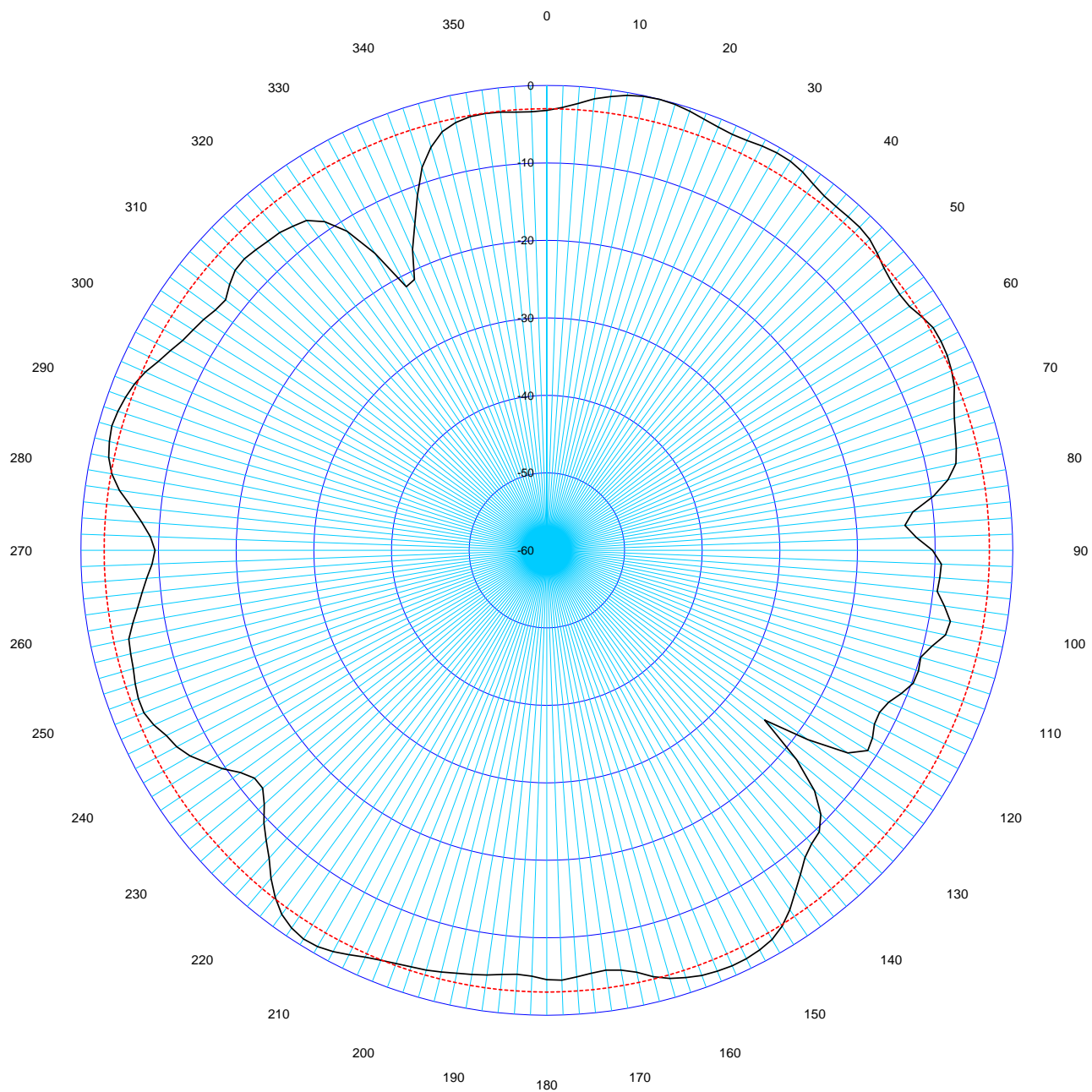


Figure 5: Antenna pattern of 2402 MHz in EUT position X and vertical polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -2.3 dBm.

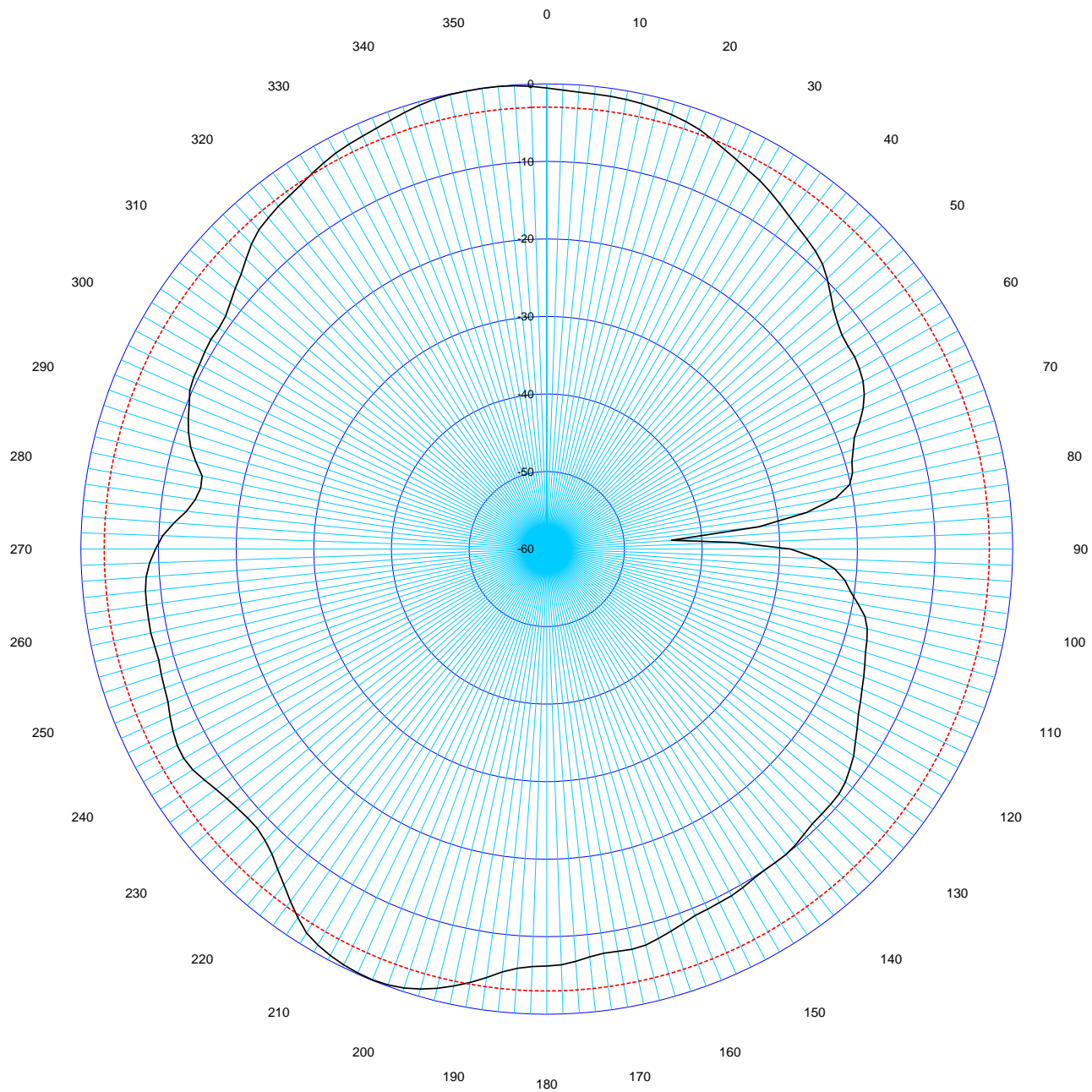


Figure 6: Antenna pattern of 2402 MHz in EUT position Y and horizontal polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -9.4 dBm.

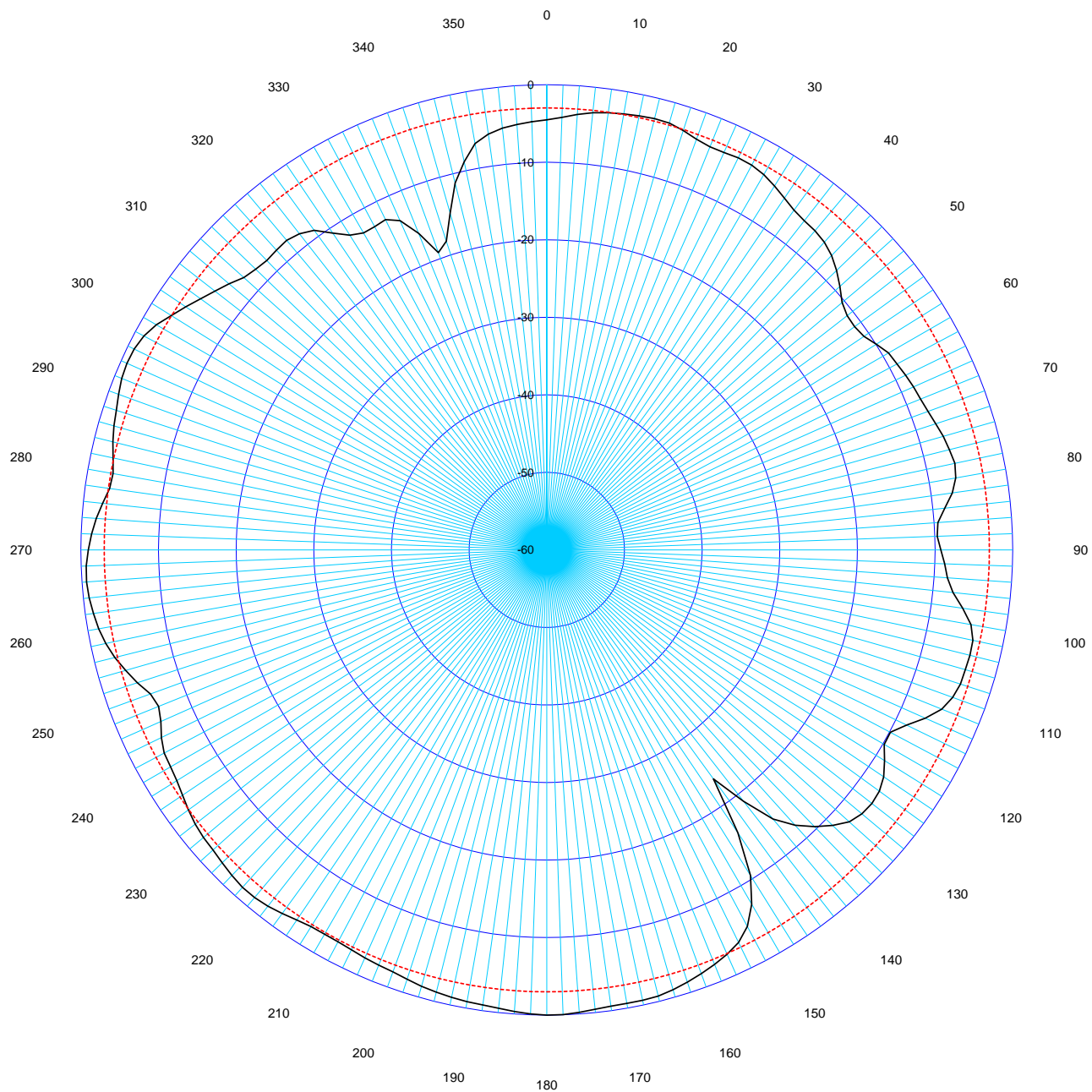


Figure 7: Antenna pattern of 2402 MHz in EUT position Y and vertical polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -9.6 dBm.

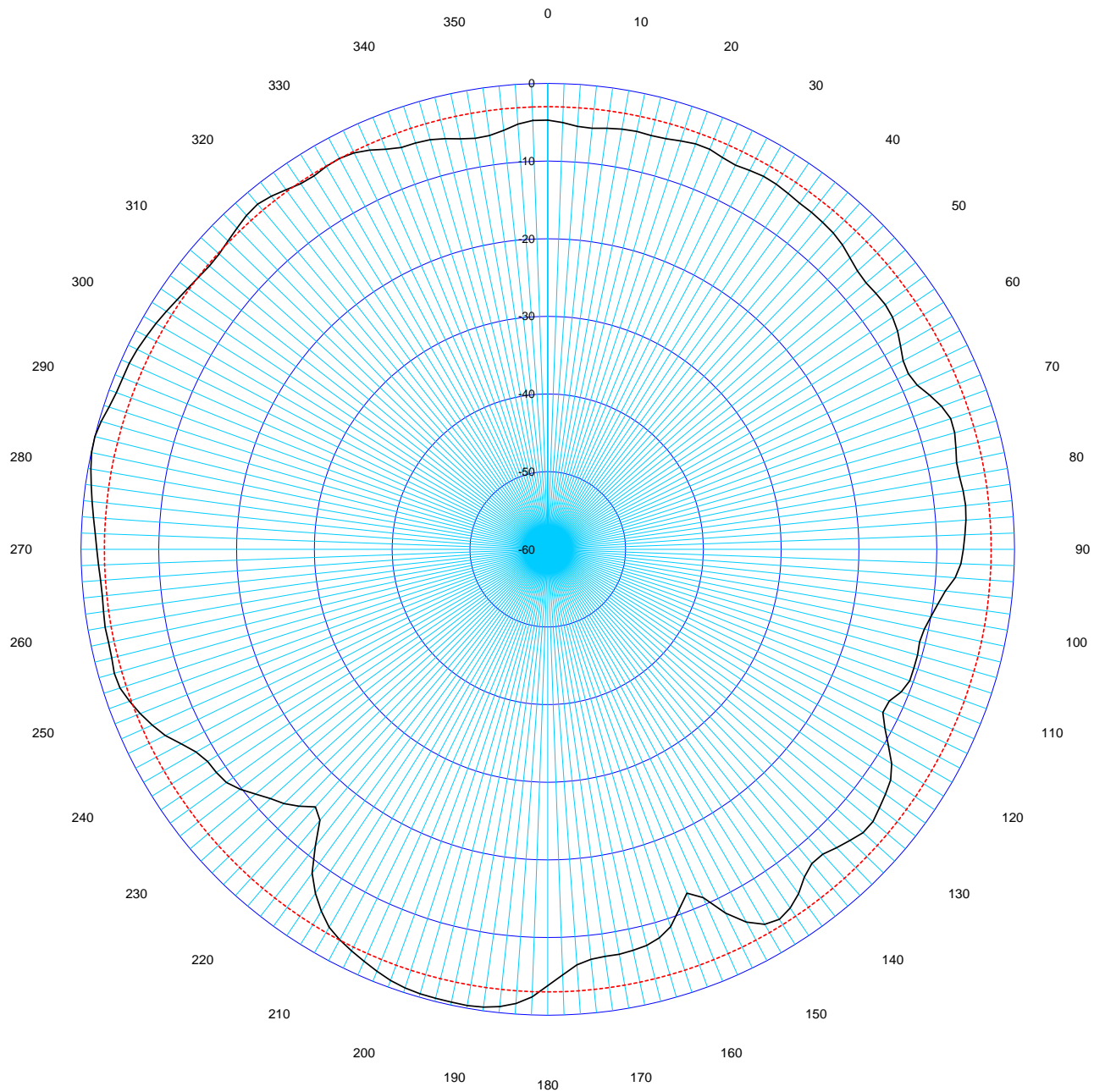


Figure 8: Antenna pattern of 2402 MHz in EUT position Z and horizontal polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -3.2 dBm.

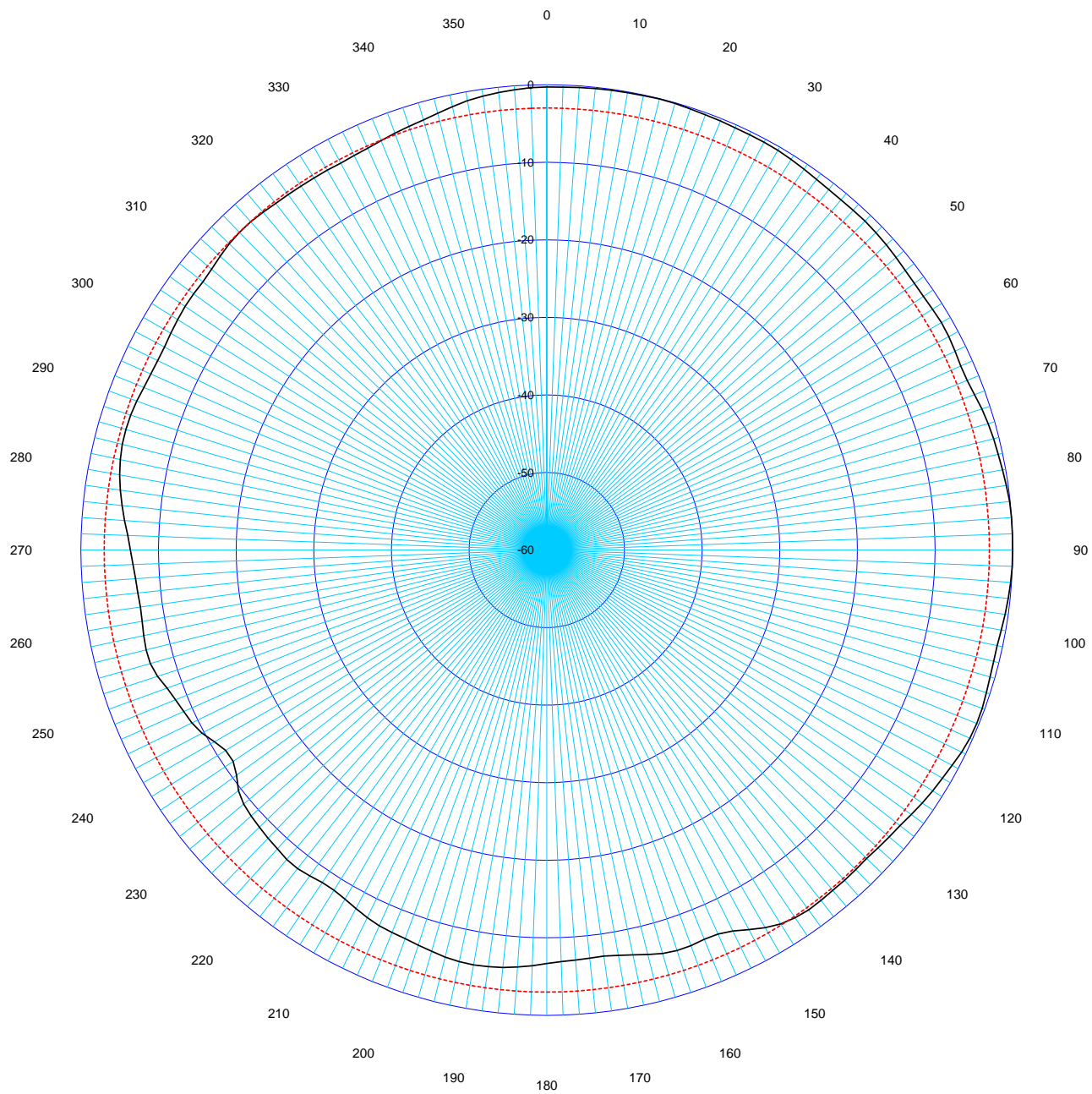


Figure 9: Antenna pattern of 2402 MHz in EUT position Z and vertical polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -3.9 dBm.

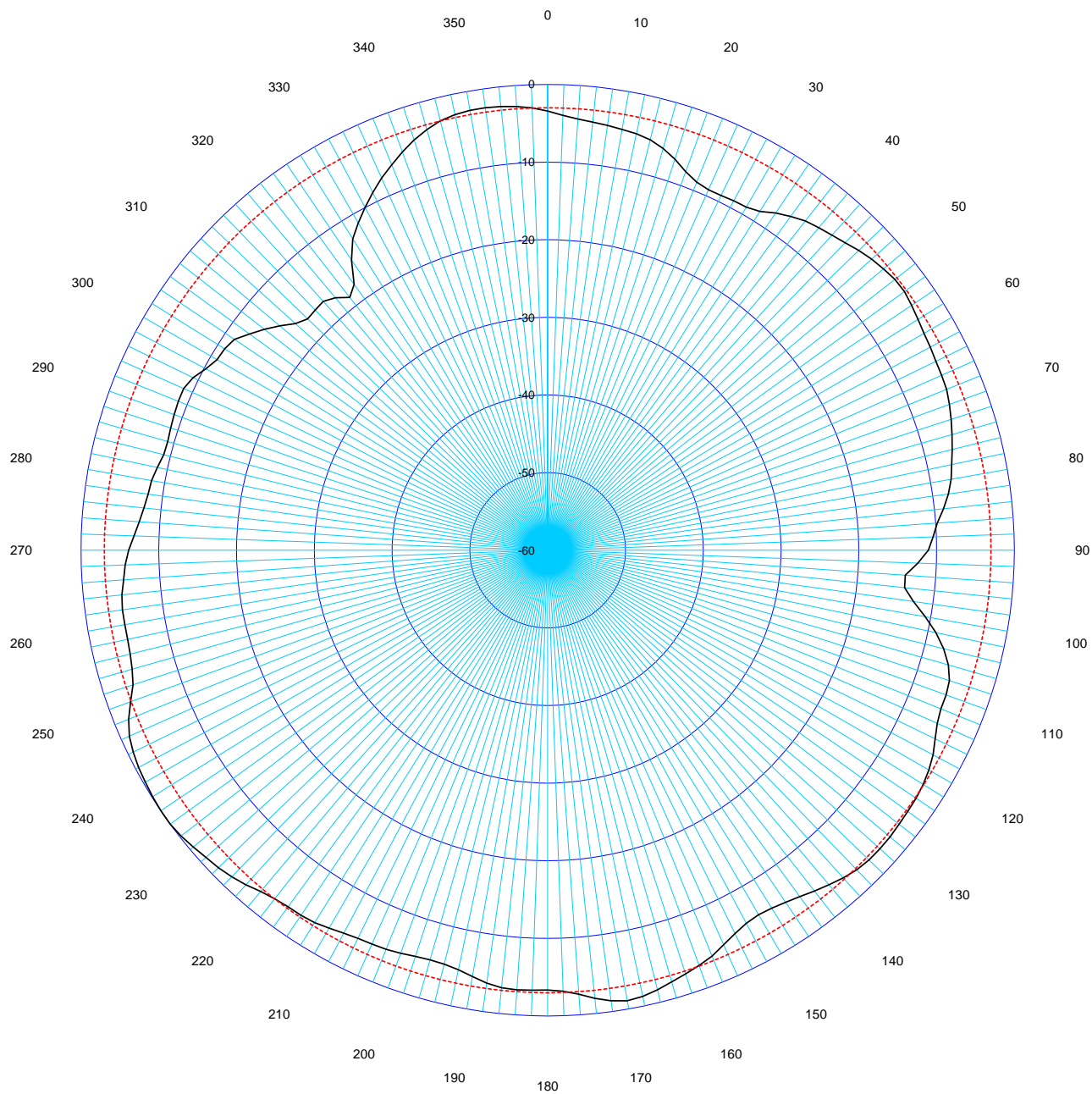


Figure 10: Antenna pattern of 2440 MHz in EUT position X and horizontal polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -9.2 dBm.

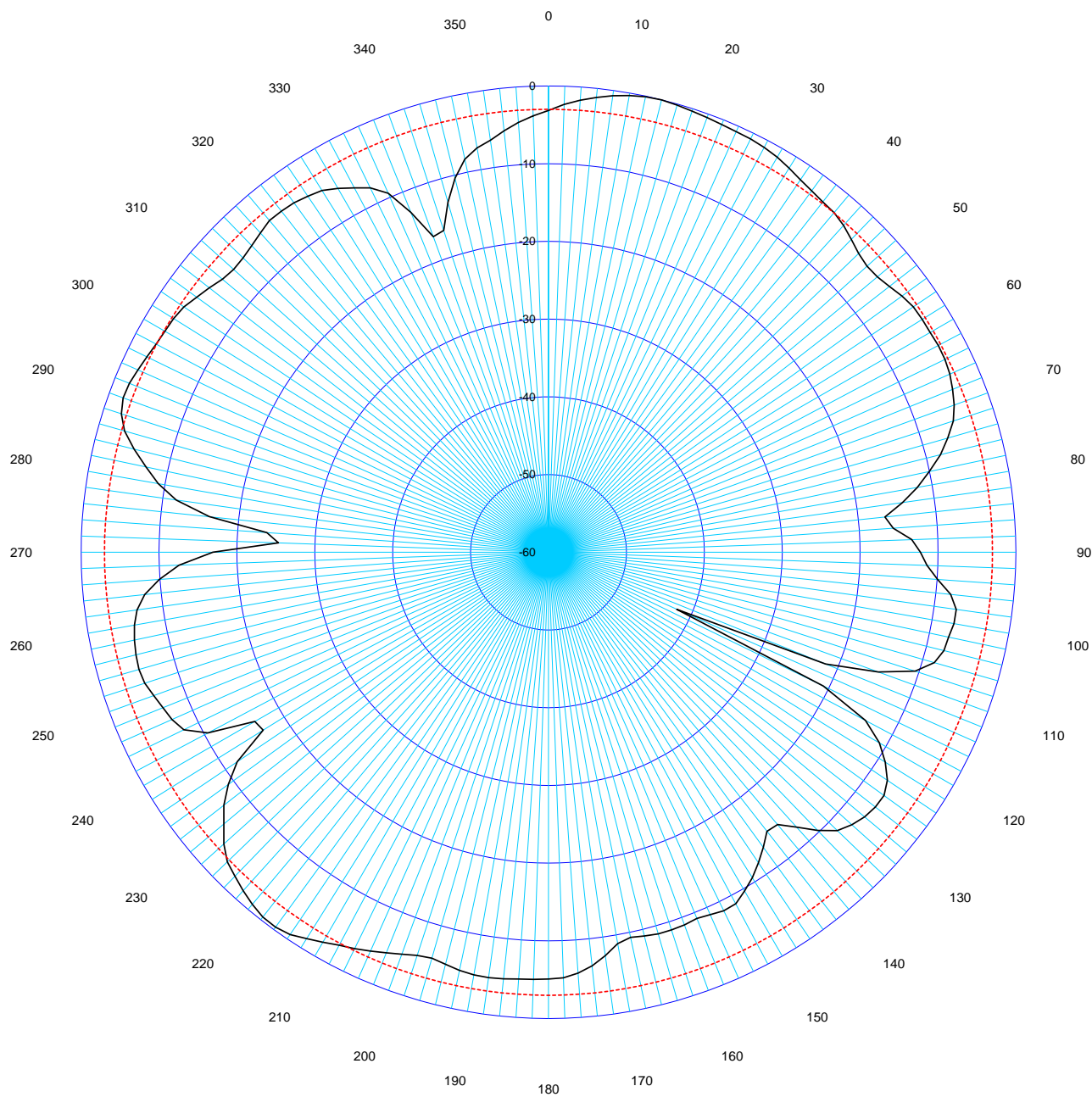


Figure 11: Antenna pattern of 2440 MHz in EUT position X and vertical polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -1.6 dBm.

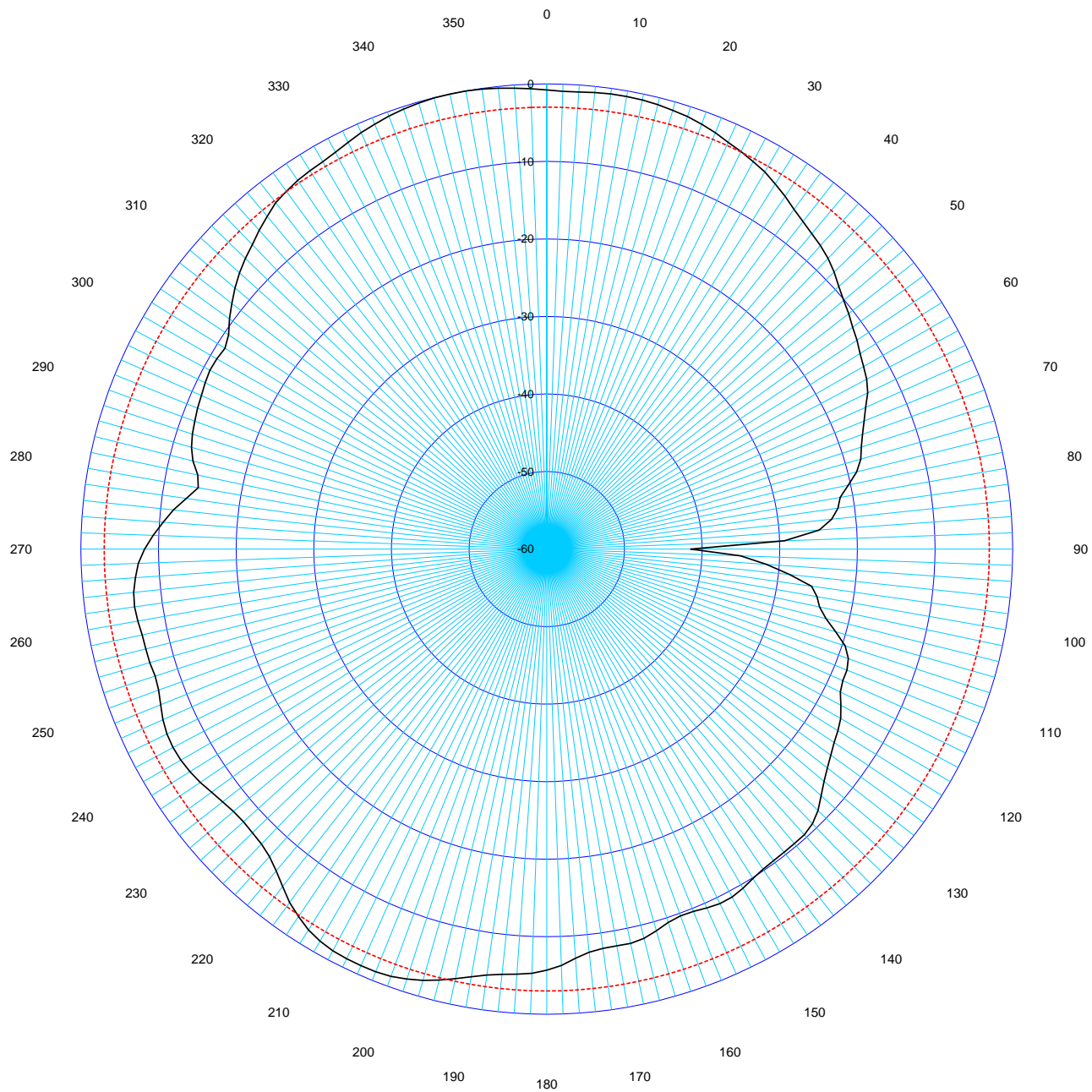


Figure 12: Antenna pattern of 2440MHz in EUT position Y and horizontal polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -9.5 dBm.

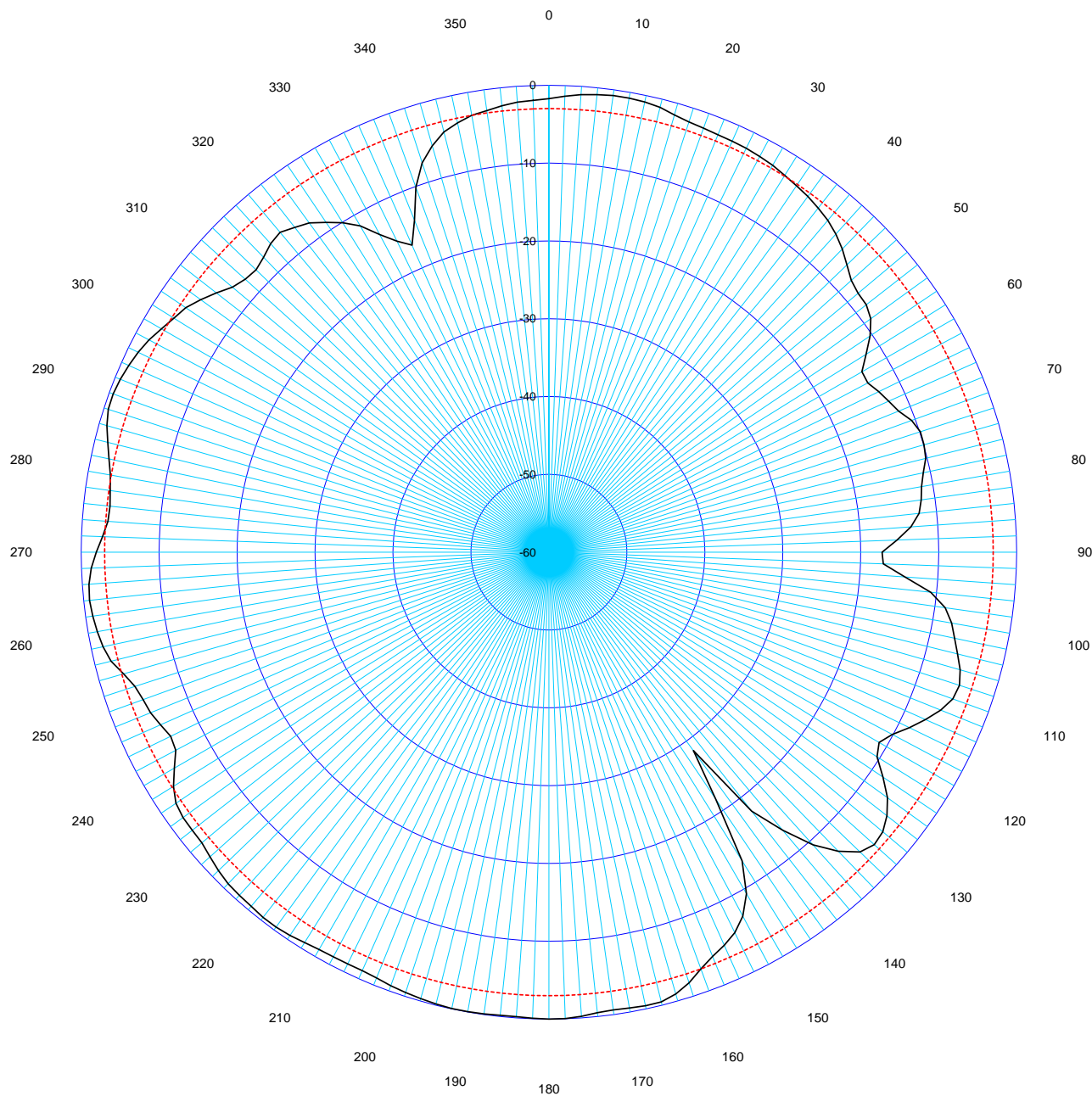


Figure 13: Antenna pattern of 2440MHz in EUT position Y and vertical polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -8.6 dBm.

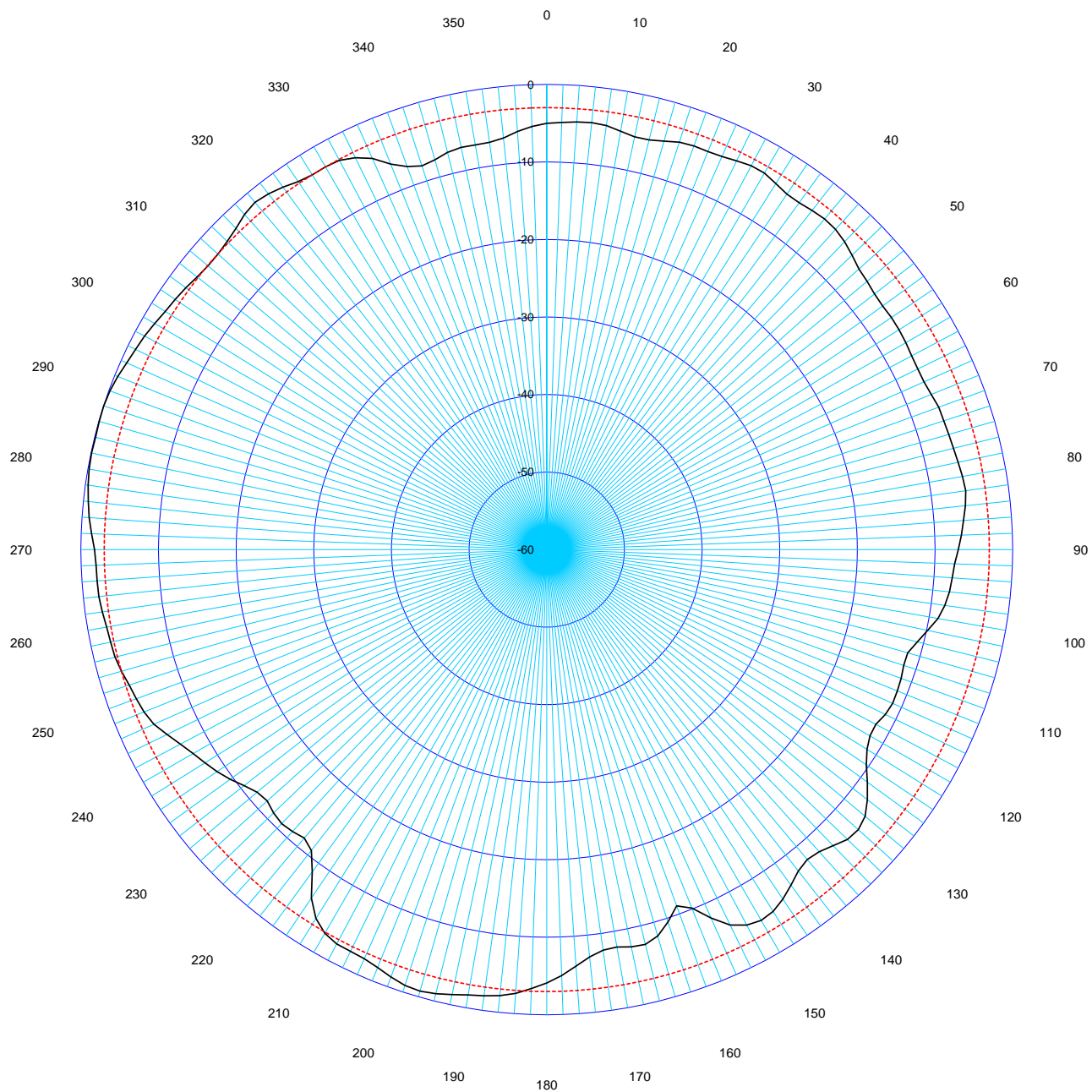


Figure 14: Antenna pattern of 2440MHz in EUT position Z and horizontal polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -2.2 dBm.

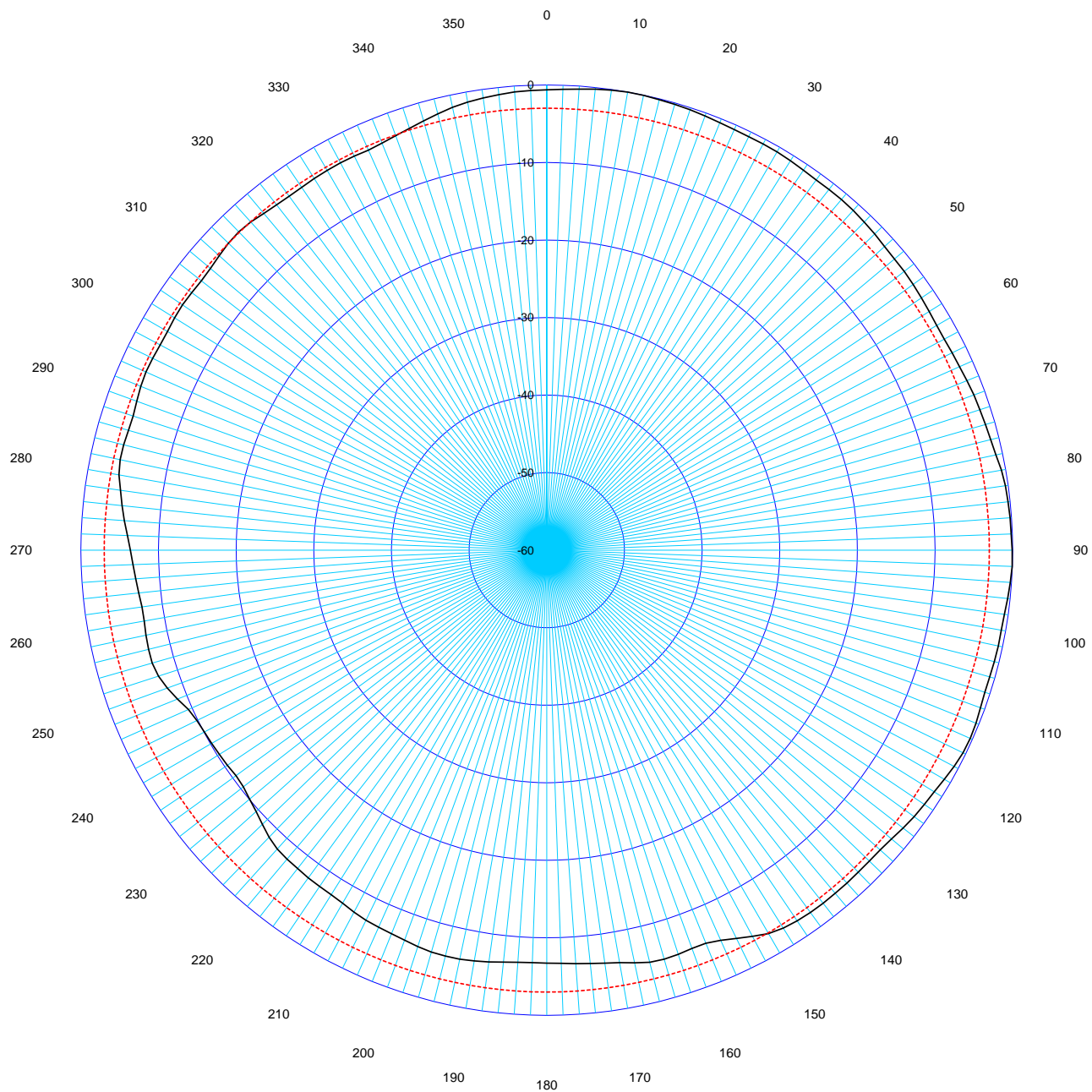


Figure 15: Antenna pattern of 2440MHz in EUT position Z and vertical polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -2.9 dBm.

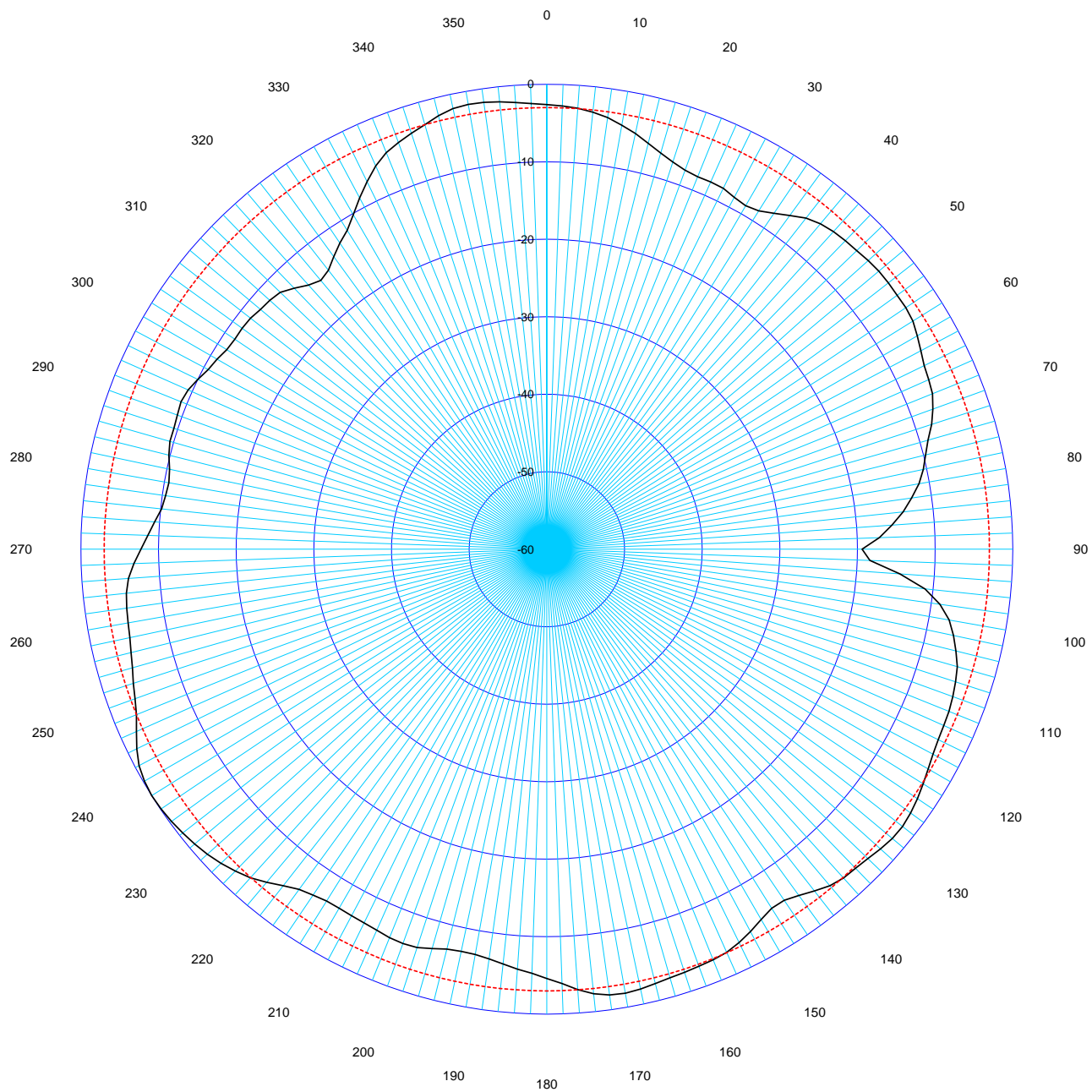


Figure 16: Antenna pattern of 2480 MHz in EUT position X and horizontal polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -8.2 dBm.

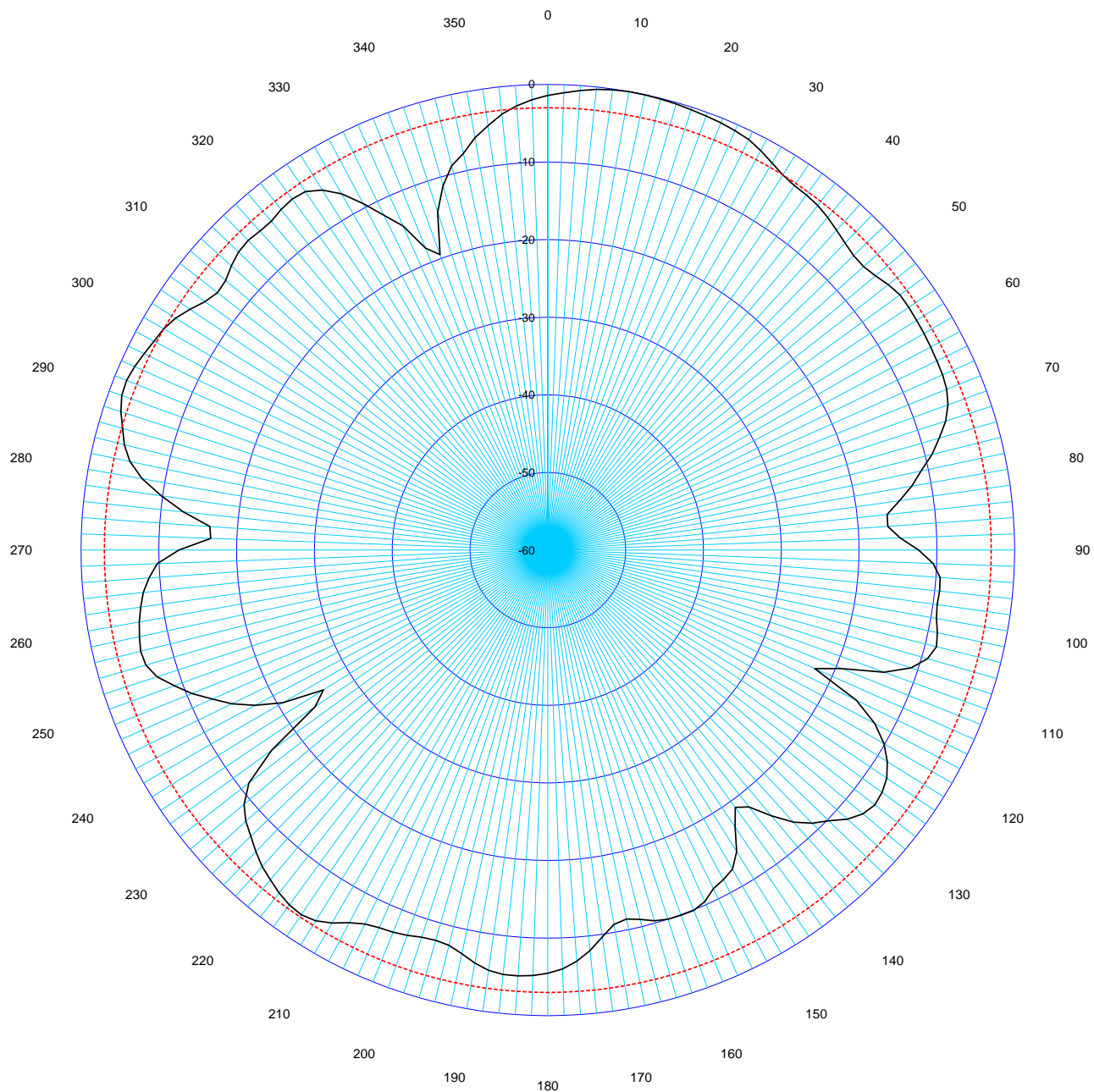


Figure 17: Antenna pattern of 2480 MHz in EUT position X and vertical polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -0.3 dBm.

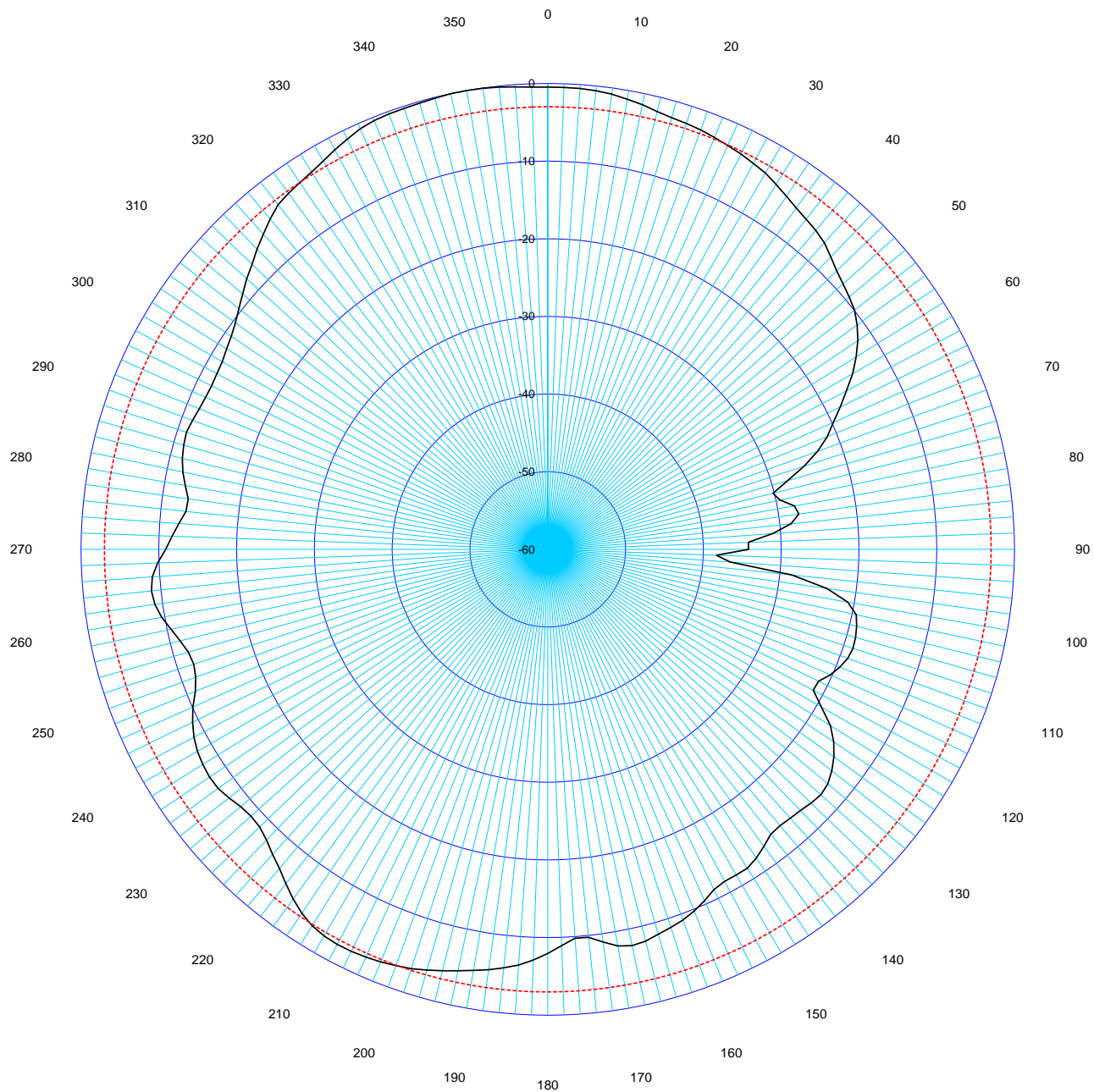


Figure 18: Antenna pattern of 2480 MHz in EUT position Y and horizontal polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -1.7 dBm.

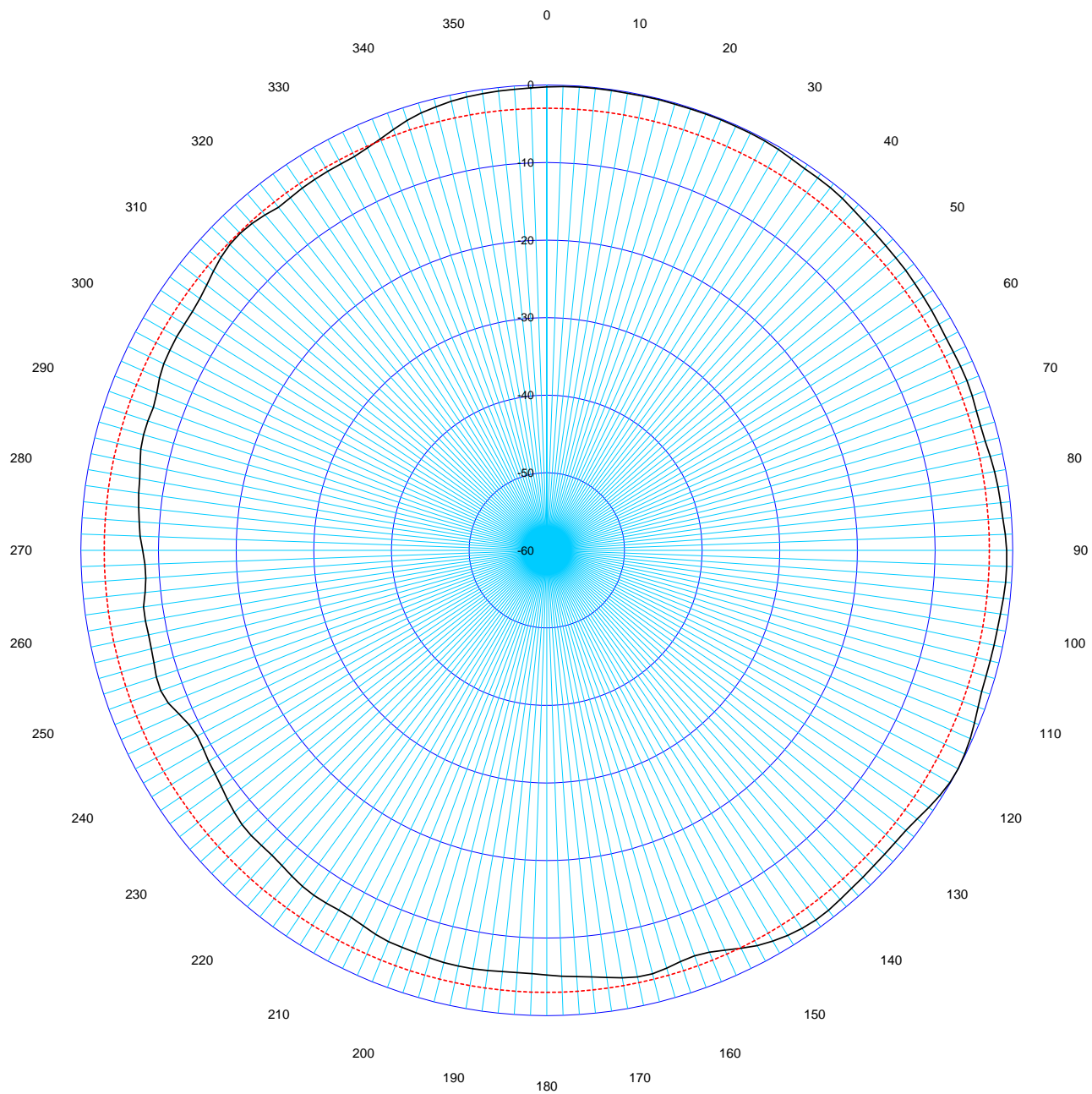


Figure 19: Antenna pattern of 2480 MHz in EUT position Y and vertical polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -6.5 dBm.

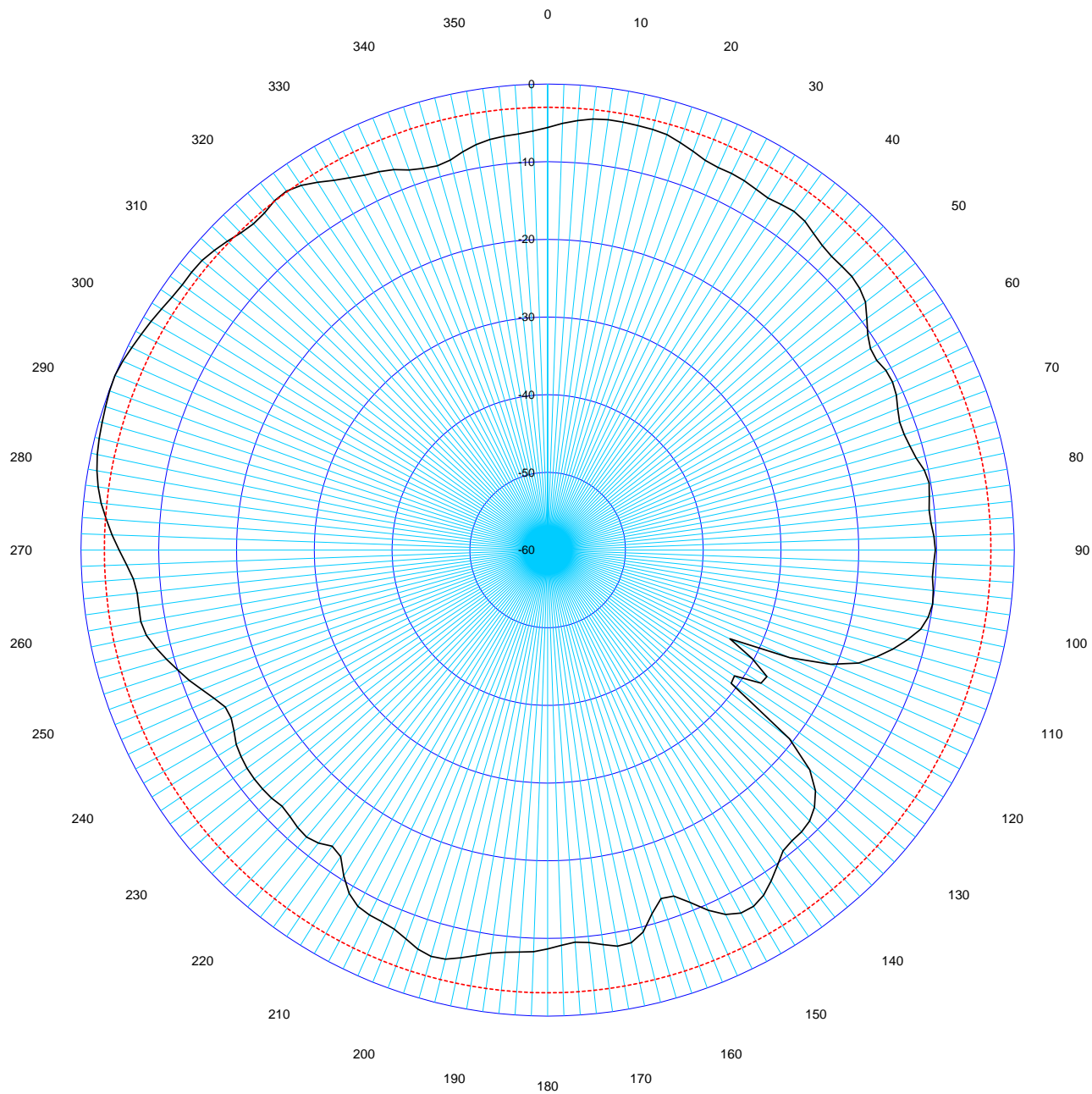


Figure 20: Antenna pattern of 2480 MHz in EUT position Z and horizontal polarisation

Note(s):

- 1 The highest EIRP of the EUT in this pattern is -1.7 dBm.

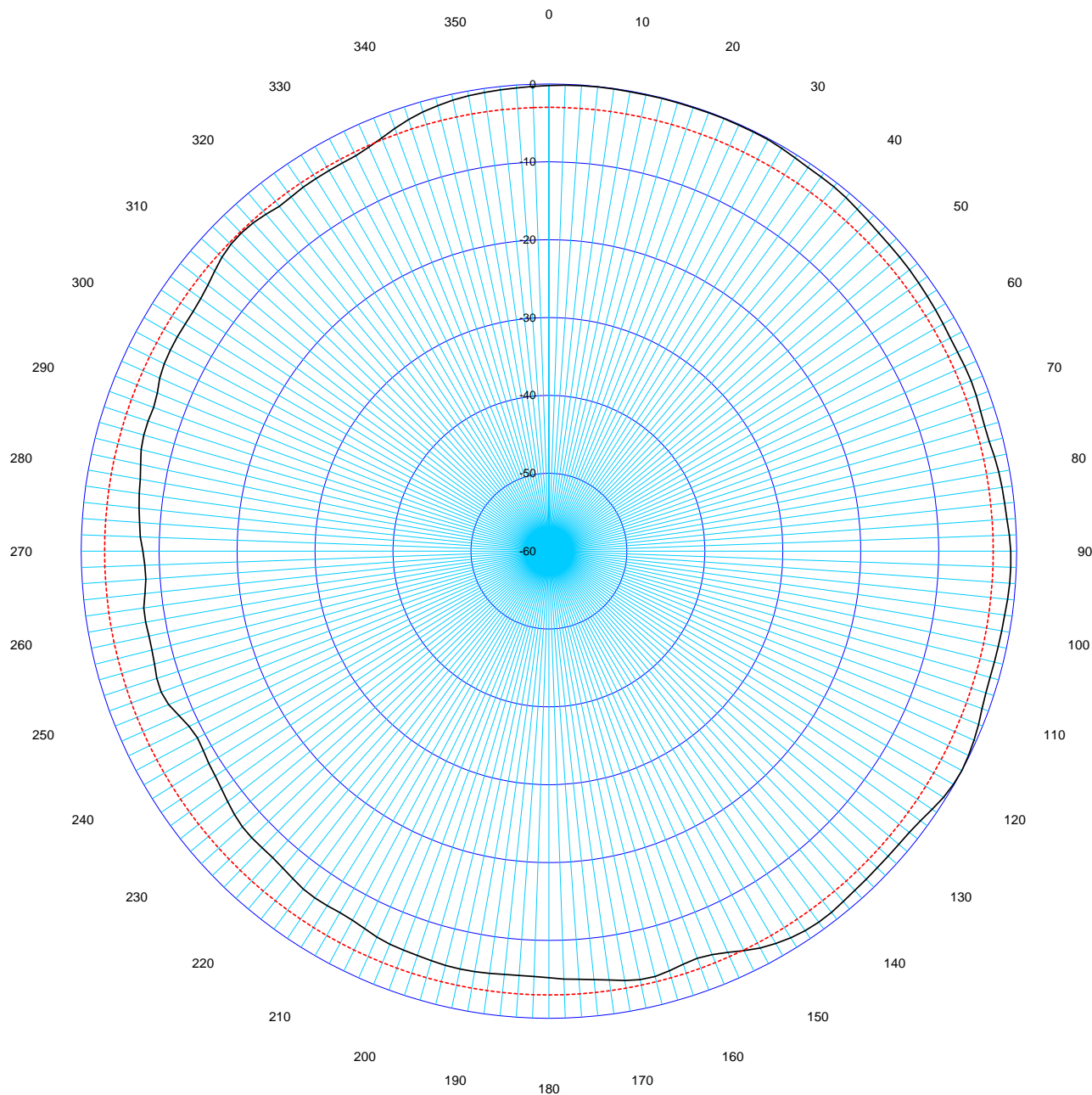


Figure 21: Antenna pattern of 2480 MHz in EUT position Z and vertical polarisation

7 Revision history

<i>Revision</i>	<i>Date</i>	<i>Issued by</i>	<i>Description of modifications</i>
0	2024-01-26	Konrad Graßl	First edition

Template: RF_Antenna tests_V1.0