

## ANNEX D PROBE CALIBRATION CERTIFICATE

**Calibration Laboratory of**  
**Schmid & Partner**  
**Engineering AG**  
Zeughausstrasse 43, 8004 Zurich, Switzerland



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **CTTL (Auden)**

Certificate No: **AM1DV2-1064\_Jul19**

### CALIBRATION CERTIFICATE

Object **AM1DV2 - SN: 1064**

Calibration procedure(s) **QA CAL-24.v4**  
**Calibration procedure for AM1D magnetic field probes and TMFS in the audio range**

Calibration date: **July 23, 2019**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards               | ID #        | Cal Date (Certificate No.)        | Scheduled Calibration |
|---------------------------------|-------------|-----------------------------------|-----------------------|
| Keithley Multimeter Type 2001   | SN: 0810278 | 03-Sep-18 (No. 23488)             | Sep-19                |
| Reference Probe AM1DV2          | SN: 1008    | 20-Dec-18 (No. AM1DV2-1008_Dec18) | Dec-19                |
| DAE4                            | SN: 781     | 09-Jan-19 (No. DAE4-781_Jan19)    | Jan-20                |
| Secondary Standards             | ID #        | Check Date (in house)             | Scheduled Check       |
| AMCC                            | SN: 1050    | 01-Oct-13 (in house check Oct-17) | Oct-19                |
| AMMI Audio Measuring Instrument | SN: 1062    | 26-Sep-12 (in house check Oct-17) | Oct-19                |

Calibrated by: **Name** **Function** **Signature**  
**Claudio Leubler** **Laboratory Technician** 

Approved by: **Katja Pokovic** **Technical Manager** 

Issued: July 23, 2019

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#### [References]

- [1] ANSI-C63.19-2007  
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.
- [2] ANSI-C63.19-2011  
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.
- [3] DASY5 manual, Chapter: Hearing Aid Compatibility (HAC) T-Coil Extension

#### Description of the AM1D probe

The AM1D Audio Magnetic Field Probe is a fully shielded magnetic field probe for the frequency range from 100 Hz to 20 kHz. The pickup coil is compliant with the dimensional requirements of [1+2]. The probe includes a symmetric low noise amplifier for the signal available at the shielded 3 pin connector at the side. Power is supplied via the same connector (phantom power supply) and monitored via the LED near the connector. The 7 pin connector at the end of the probe does not carry any signals, but determines the angle of the sensor when mounted on the DAE. The probe supports mechanical detection of the surface.

The single sensor in the probe is arranged in a tilt angle allowing measurement of 3 orthogonal field components when rotating the probe by 120° around its axis. It is aligned with the perpendicular component of the field, if the probe axis is tilted nominally 35.3° above the measurement plane, using the connector rotation and sensor angle stated below.

The probe is fully RF shielded when operated with the matching signal cable (shielded) and allows measurement of audio magnetic fields in the close vicinity of RF emitting wireless devices according to [1+2] without additional shielding.

#### Handling of the item

The probe is manufactured from stainless steel. In order to maintain the performance and calibration of the probe, it must not be opened. The probe is designed for operation in air and shall not be exposed to humidity or liquids. For proper operation of the surface detection and emergency stop functions in a DASY system, the probe must be operated with the special probe cup provided (larger diameter).

#### Methods Applied and Interpretation of Parameters

- *Coordinate System:* The AM1D probe is mounted in the DASY system for operation with a HAC Test Arch phantom with AMCC Helmholtz calibration coil according to [3], with the tip pointing to "southwest" orientation.
- *Functional Test:* The functional test preceding calibration includes test of Noise level  
RF immunity (1kHz AM modulated signal). The shield of the probe cable must be well connected.  
Frequency response verification from 100 Hz to 10 kHz.
- *Connector Rotation:* The connector at the end of the probe does not carry any signals and is used for fixation to the DAE only. The probe is operated in the center of the AMCC Helmholtz coil using a 1 kHz magnetic field signal. Its angle is determined from the two minima at nominally +120° and -120° rotation, so the sensor in the tip of the probe is aligned to the vertical plane in z-direction, corresponding to the field maximum in the AMCC Helmholtz calibration coil.
- *Sensor Angle:* The sensor tilting in the vertical plane from the ideal vertical direction is determined from the two minima at nominally +120° and -120°. DASY system uses this angle to align the sensor for radial measurements to the x and y axis in the horizontal plane.

*Sensitivity:* With the probe sensor aligned to the z-field in the AMCC, the output of the probe is compared to the magnetic field in the AMCC at 1 kHz. The field in the AMCC Helmholtz coil is given by the geometry and the current through the coil, which is monitored on the precision shunt resistor of the coil.

**AM1D probe identification and configuration data**

|           |                                             |
|-----------|---------------------------------------------|
| Item      | <b>AM1DV2</b> Audio Magnetic 1D Field Probe |
| Type No   | SP AM1 001 AF                               |
| Serial No | <b>1064</b>                                 |

|                    |                                    |
|--------------------|------------------------------------|
| Overall length     | 296 mm                             |
| Tip diameter       | 6.0 mm (at the tip)                |
| Sensor offset      | 3.0 mm (centre of sensor from tip) |
| Internal Amplifier | 40 dB                              |

|                       |                                                      |
|-----------------------|------------------------------------------------------|
| Manufacturer / Origin | Schmid & Partner Engineering AG, Zurich, Switzerland |
|-----------------------|------------------------------------------------------|

**Calibration data**

|                          |                  |                       |                 |
|--------------------------|------------------|-----------------------|-----------------|
| Connector rotation angle | (in DASY system) | <b>103.0°</b>         | +/- 3.6 ° (k=2) |
| Sensor angle             | (in DASY system) | <b>0.63°</b>          | +/- 0.5 ° (k=2) |
| Sensitivity at 1 kHz     | (in DASY system) | <b>0.0657 V/(A/m)</b> | +/- 2.2 % (k=2) |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## ANNEX E DAE CALIBRATION CERTIFICATE

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Accreditation No.: **SCS 0108**

Client **CTTL - BJ (Auden)**

Certificate No: **DAE4-1555\_Aug18**

### CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BN - SN: 1555**

Calibration procedure(s) **QA CAL-06.v29  
Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **August 20, 2018**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature  $(22 \pm 3)^{\circ}\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards             | ID #               | Cal Date (Certificate No.) | Scheduled Calibration  |
|-------------------------------|--------------------|----------------------------|------------------------|
| Keithley Multimeter Type 2001 | SN: 0810278        | 31-Aug-17 (No:21092)       | Aug-18                 |
| Secondary Standards           | ID #               | Check Date (in house)      | Scheduled Check        |
| Auto DAE Calibration Unit     | SE UWS 053 AA 1001 | 04-Jan-18 (in house check) | In house check: Jan-19 |
| Calibrator Box V2.1           | SE UMS 006 AA 1002 | 04-Jan-18 (in house check) | In house check: Jan-19 |

|                |                        |                                   |                                                                                                    |
|----------------|------------------------|-----------------------------------|----------------------------------------------------------------------------------------------------|
| Calibrated by: | Name<br>Adrian Gehring | Function<br>Laboratory Technician | Signature<br> |
| Approved by:   | Sven Kühn              | Deputy Manager                    |               |

Issued: August 20, 2018

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Accreditation No.: **SCS 0108**

## Glossary

DAE data acquisition electronics  
Connector angle information used in DASY system to align probe sensor X to the robot coordinate system.

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement:* Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

**DC Voltage Measurement**

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 $\mu$ V, full range = -100...+300 mV

Low Range: 1LSB = 61nV, full range = -1.....+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X                         | Y                         | Z                         |
|---------------------|---------------------------|---------------------------|---------------------------|
| High Range          | 404.540 $\pm$ 0.02% (k=2) | 404.077 $\pm$ 0.02% (k=2) | 405.023 $\pm$ 0.02% (k=2) |
| Low Range           | 3.92909 $\pm$ 1.50% (k=2) | 3.94558 $\pm$ 1.50% (k=2) | 3.97891 $\pm$ 1.50% (k=2) |

**Connector Angle**

|                                           |                                     |
|-------------------------------------------|-------------------------------------|
| Connector Angle to be used in DASY system | 104.0 $^{\circ}$ $\pm$ 1 $^{\circ}$ |
|-------------------------------------------|-------------------------------------|

**Appendix (Additional assessments outside the scope of SCS0108)**

**1. DC Voltage Linearity**

| High Range        | Reading ( $\mu\text{V}$ ) | Difference ( $\mu\text{V}$ ) | Error (%) |
|-------------------|---------------------------|------------------------------|-----------|
| Channel X + Input | 199994.32                 | -1.11                        | -0.00     |
| Channel X + Input | 20004.21                  | 2.27                         | 0.01      |
| Channel X - Input | -19994.21                 | 6.72                         | -0.03     |
| Channel Y + Input | 199991.01                 | -4.74                        | -0.00     |
| Channel Y + Input | 19999.15                  | -2.66                        | -0.01     |
| Channel Y - Input | -19999.37                 | 1.70                         | -0.01     |
| Channel Z + Input | 199997.50                 | 1.46                         | 0.00      |
| Channel Z + Input | 19998.75                  | -3.06                        | -0.02     |
| Channel Z - Input | -20003.08                 | -1.96                        | 0.01      |

| Low Range         | Reading ( $\mu\text{V}$ ) | Difference ( $\mu\text{V}$ ) | Error (%) |
|-------------------|---------------------------|------------------------------|-----------|
| Channel X + Input | 2001.23                   | -0.12                        | -0.01     |
| Channel X + Input | 201.73                    | 0.03                         | 0.02      |
| Channel X - Input | -197.79                   | 0.32                         | -0.16     |
| Channel Y + Input | 2001.22                   | 0.00                         | 0.00      |
| Channel Y + Input | 201.15                    | -0.62                        | -0.31     |
| Channel Y - Input | -198.47                   | -0.28                        | 0.14      |
| Channel Z + Input | 2001.41                   | 0.23                         | 0.01      |
| Channel Z + Input | 200.99                    | -0.67                        | -0.33     |
| Channel Z - Input | -199.42                   | -1.11                        | 0.56      |

**2. Common mode sensitivity**

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | Common mode Input Voltage (mV) | High Range Average Reading ( $\mu\text{V}$ ) | Low Range Average Reading ( $\mu\text{V}$ ) |
|-----------|--------------------------------|----------------------------------------------|---------------------------------------------|
| Channel X | 200                            | -10.02                                       | -11.33                                      |
|           | - 200                          | 12.53                                        | 10.76                                       |
| Channel Y | 200                            | 10.66                                        | 10.40                                       |
|           | - 200                          | -12.33                                       | -12.29                                      |
| Channel Z | 200                            | -2.18                                        | -2.52                                       |
|           | - 200                          | 0.20                                         | -0.09                                       |

**3. Channel separation**

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | Input Voltage (mV) | Channel X ( $\mu\text{V}$ ) | Channel Y ( $\mu\text{V}$ ) | Channel Z ( $\mu\text{V}$ ) |
|-----------|--------------------|-----------------------------|-----------------------------|-----------------------------|
| Channel X | 200                | -                           | -0.85                       | -2.68                       |
| Channel Y | 200                | 8.65                        | -                           | 0.04                        |
| Channel Z | 200                | 6.10                        | 6.93                        | -                           |

#### 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | High Range (LSB) | Low Range (LSB) |
|-----------|------------------|-----------------|
| Channel X | 15635            | 14959           |
| Channel Y | 15850            | 16040           |
| Channel Z | 16635            | 16604           |

#### 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input 10M $\Omega$

|           | Average ( $\mu$ V) | min. Offset ( $\mu$ V) | max. Offset ( $\mu$ V) | Std. Deviation ( $\mu$ V) |
|-----------|--------------------|------------------------|------------------------|---------------------------|
| Channel X | 0.40               | -0.72                  | 1.60                   | 0.48                      |
| Channel Y | 0.06               | -0.99                  | 1.84                   | 0.46                      |
| Channel Z | -0.76              | -2.17                  | 0.18                   | 0.48                      |

#### 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

#### 7. Input Resistance (Typical values for information)

|           | Zeroing (kOhm) | Measuring (MOhm) |
|-----------|----------------|------------------|
| Channel X | 200            | 200              |
| Channel Y | 200            | 200              |
| Channel Z | 200            | 200              |

#### 8. Low Battery Alarm Voltage (Typical values for information)

| Typical values | Alarm Level (VDC) |
|----------------|-------------------|
| Supply (+ Vcc) | +7.9              |
| Supply (- Vcc) | -7.6              |

#### 9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|----------------|-------------------|---------------|-------------------|
| Supply (+ Vcc) | +0.01             | +6            | +14               |
| Supply (- Vcc) | -0.01             | -8            | -9                |

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Accreditation No.: **SCS 0108**

Client **CTTL (Auden)**

Certificate No: **DAE4-1331\_Feb19**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 1331**

Calibration procedure(s) **QA CAL-06.v29**  
**Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **February 06, 2019**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards             | ID #               | Cal Date (Certificate No.) | Scheduled Calibration  |
|-------------------------------|--------------------|----------------------------|------------------------|
| Keithley Multimeter Type 2001 | SN: 0810278        | 03-Sep-18 (No:23488)       | Sep-19                 |
| Secondary Standards           | ID #               | Check Date (in house)      | Scheduled Check        |
| Auto DAE Calibration Unit     | SE UWS 053 AA 1001 | 07-Jan-19 (in house check) | In house check: Jan-20 |
| Calibrator Box V2.1           | SE UMS 006 AA 1002 | 07-Jan-19 (in house check) | In house check: Jan-20 |

|                |                           |                                   |                                                                                                    |
|----------------|---------------------------|-----------------------------------|----------------------------------------------------------------------------------------------------|
| Calibrated by: | Name<br>Dominique Steffen | Function<br>Laboratory Technician | Signature<br> |
| Approved by:   | Sven Kühn                 | Deputy Manager                    |               |

Issued: February 6, 2019

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## Glossary

DAE data acquisition electronics  
Connector angle information used in DASY system to align probe sensor X to the robot coordinate system.

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement:* Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

### DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 $\mu$ V, full range = -100...+300 mV

Low Range: 1LSB = 61nV, full range = -1.....+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X                         | Y                         | Z                         |
|---------------------|---------------------------|---------------------------|---------------------------|
| High Range          | 405.242 $\pm$ 0.02% (k=2) | 405.315 $\pm$ 0.02% (k=2) | 405.081 $\pm$ 0.02% (k=2) |
| Low Range           | 3.95572 $\pm$ 1.50% (k=2) | 3.99448 $\pm$ 1.50% (k=2) | 4.01838 $\pm$ 1.50% (k=2) |

### Connector Angle

|                                           |                   |
|-------------------------------------------|-------------------|
| Connector Angle to be used in DASY system | 197.0 ° $\pm$ 1 ° |
|-------------------------------------------|-------------------|

## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

| High Range        | Reading ( $\mu\text{V}$ ) | Difference ( $\mu\text{V}$ ) | Error (%) |
|-------------------|---------------------------|------------------------------|-----------|
| Channel X + Input | 199996.03                 | 0.96                         | 0.00      |
| Channel X + Input | 20003.08                  | 1.84                         | 0.01      |
| Channel X - Input | -19999.52                 | 2.43                         | -0.01     |
| Channel Y + Input | 199998.14                 | 2.99                         | 0.00      |
| Channel Y + Input | 20001.08                  | -0.05                        | -0.00     |
| Channel Y - Input | -20002.02                 | -0.04                        | 0.00      |
| Channel Z + Input | 199996.50                 | 1.66                         | 0.00      |
| Channel Z + Input | 19999.11                  | -2.09                        | -0.01     |
| Channel Z - Input | -20003.68                 | -1.62                        | 0.01      |

| Low Range         | Reading ( $\mu\text{V}$ ) | Difference ( $\mu\text{V}$ ) | Error (%) |
|-------------------|---------------------------|------------------------------|-----------|
| Channel X + Input | 2001.08                   | 0.43                         | 0.02      |
| Channel X + Input | 200.82                    | -0.32                        | -0.16     |
| Channel X - Input | -198.42                   | 0.17                         | -0.09     |
| Channel Y + Input | 2000.70                   | 0.02                         | 0.00      |
| Channel Y + Input | 200.61                    | -0.46                        | -0.23     |
| Channel Y - Input | -199.76                   | -1.08                        | 0.54      |
| Channel Z + Input | 2000.97                   | 0.31                         | 0.02      |
| Channel Z + Input | 199.83                    | -1.19                        | -0.59     |
| Channel Z - Input | -200.44                   | -1.65                        | 0.83      |

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | Common mode Input Voltage (mV) | High Range Average Reading ( $\mu\text{V}$ ) | Low Range Average Reading ( $\mu\text{V}$ ) |
|-----------|--------------------------------|----------------------------------------------|---------------------------------------------|
| Channel X | 200                            | 25.44                                        | 23.80                                       |
|           | - 200                          | -24.57                                       | -26.00                                      |
| Channel Y | 200                            | 4.40                                         | 4.15                                        |
|           | - 200                          | -5.34                                        | -5.32                                       |
| Channel Z | 200                            | -0.55                                        | -0.75                                       |
|           | - 200                          | -1.27                                        | -1.71                                       |

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | Input Voltage (mV) | Channel X ( $\mu\text{V}$ ) | Channel Y ( $\mu\text{V}$ ) | Channel Z ( $\mu\text{V}$ ) |
|-----------|--------------------|-----------------------------|-----------------------------|-----------------------------|
| Channel X | 200                | -                           | 6.56                        | -0.39                       |
| Channel Y | 200                | 8.71                        | -                           | 7.04                        |
| Channel Z | 200                | 7.79                        | 6.66                        | -                           |

#### 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | High Range (LSB) | Low Range (LSB) |
|-----------|------------------|-----------------|
| Channel X | 15607            | 16065           |
| Channel Y | 15909            | 15986           |
| Channel Z | 16038            | 16066           |

#### 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input 10M $\Omega$

|           | Average ( $\mu$ V) | min. Offset ( $\mu$ V) | max. Offset ( $\mu$ V) | Std. Deviation ( $\mu$ V) |
|-----------|--------------------|------------------------|------------------------|---------------------------|
| Channel X | 0.45               | -0.89                  | 2.06                   | 0.59                      |
| Channel Y | -0.92              | -2.20                  | -0.12                  | 0.36                      |
| Channel Z | 0.53               | -0.85                  | 2.06                   | 0.51                      |

#### 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

#### 7. Input Resistance (Typical values for information)

|           | Zeroing (kOhm) | Measuring (MOhm) |
|-----------|----------------|------------------|
| Channel X | 200            | 200              |
| Channel Y | 200            | 200              |
| Channel Z | 200            | 200              |

#### 8. Low Battery Alarm Voltage (Typical values for information)

| Typical values | Alarm Level (VDC) |
|----------------|-------------------|
| Supply (+ Vcc) | +7.9              |
| Supply (- Vcc) | -7.6              |

#### 9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|----------------|-------------------|---------------|-------------------|
| Supply (+ Vcc) | +0.01             | +6            | +14               |
| Supply (- Vcc) | -0.01             | -8            | -9                |

## ANNEX F THE EVALUATION OF SPOTCHECK AND GOOGLE DUO

### F.1 The spot check results

**Table F-1 Test results for 2/3G**

| Probe Position | Band      | Ch.  | Measurement Position (x mm, y mm) | ABM1 (dB A/m) | SNR (dB) | T category |
|----------------|-----------|------|-----------------------------------|---------------|----------|------------|
| transverse     | GSM 850   | 190  | -5.8,12.5                         | -4.19         | 42.16    | T4         |
|                | WCDMA1900 | 9400 | -2.9,-4.2                         | -5.41         | 49.97    | T4         |
| perpendicular  | GSM 850   | 190  | 3.3,4.6                           | 7.47          | 42.93    | T4         |
|                | WCDMA1900 | 9400 | -0.4,6.2                          | 5.39          | 51.83    | T4         |

Note:

1. Bluetooth and WiFi function is turn off and microphone is muted.
2. Signal strength measurement scan plots are presented in Annex B.
3. The volume is adjusted to maximum level during T-Coil testing.

**Table F-2 Test results for LTE**

| Probe Position | Band   | Ch.   | Bandwidth | Measurement Position (x mm, y mm) | ABM1 (dB A/m) | SNR (dB) | T category |
|----------------|--------|-------|-----------|-----------------------------------|---------------|----------|------------|
| Transverse     | LTE B4 | 20175 | 20M       | 2.5,12.5                          | -0.44         | 59.06    | T4         |
| Perpendicular  | LTE B2 | 18900 | 20M       | -0.4,6.2                          | 5.47          | 46.48    | T4         |

Note:

1. Bluetooth and WiFi function is turn off and microphone is muted.
2. The worse case of each band for signal strength measurement scan plots are presented in Annex B.
3. The volume is adjusted to maximum level during T-Coil testing.

**Table F-3 Test results for WiFi**

| Probe Position | Mode    | Ch. | Bandwidth | Measurement Position (x mm, y mm) | ABM1 (dB A/m) | SNR (dB) | Category T ? |
|----------------|---------|-----|-----------|-----------------------------------|---------------|----------|--------------|
| Transverse     | 802.11n | 6   | 20M       | -5.5, 9.7                         | -2.01         | 42.76    | T4           |
| Perpendicular  | 802.11n | 6   | 20M       | -0.9, 6.6                         | 5.65          | 46.57    | T4           |

Note:

1. Bluetooth and WiFi function is turn off and microphone is muted.
2. The worse case of each mode for signal strength measurement scan plots are presented in Annex B.
3. The volume is adjusted to maximum level during T-Coil testing.

## F.2 OTT VoIP test system and DUT configuration

### F.2.1 Test System Setup for OTT VoIP T-coil Testing

#### General Note:

Regards the protocols, Google Duo, the highlighting section of the test set up, reference levels used, codec(s) and the fact that an investigation was done to determine the worst-case codec/rate documented in the test results below.

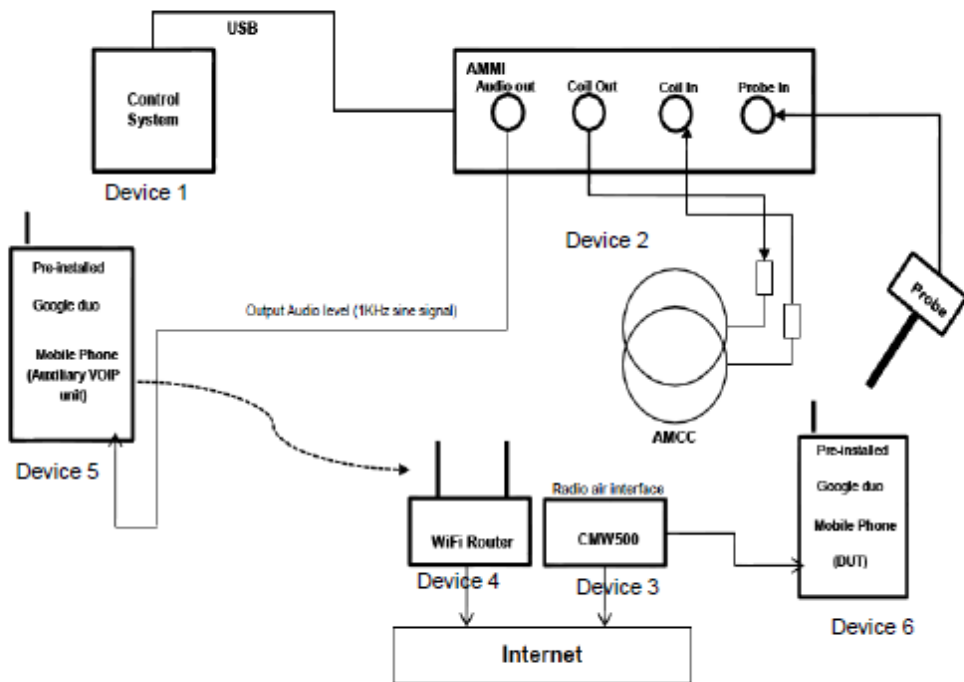
#### OTT VoIP Application

Google Duo is a pre-installed application on the DUT which allows for VoIP calls in a head-to-ear scenario. Duo uses the OPUS audio codec and supports a bitrate range of 6kbps to 75kbps. All air interfaces capable of a data connection were evaluated with Google Duo. When HAC testing we are using the Google Duo version is 26.0.179825522.alpha.DEV and the bitrate configuration can find at settings → Voice call parameters settings → Audio codec bitrate(6-75kbps).

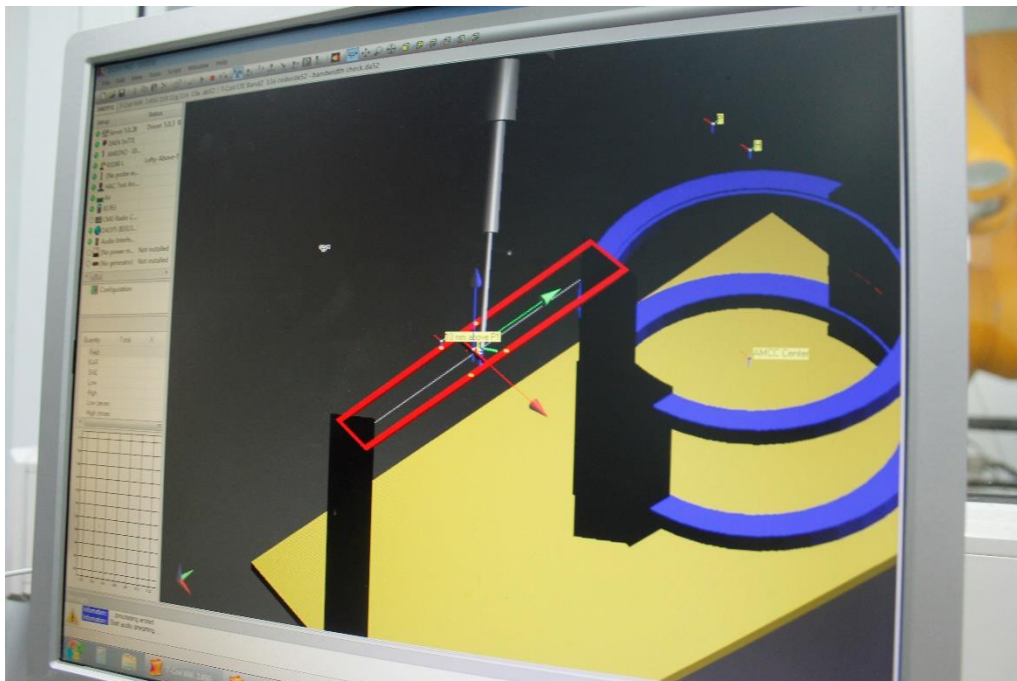
#### Test Procedure and Equipment Setup

The test procedure for OTT testing is identical to the section above, except for how the signal is sent to the DUT, as outlined in the diagram below.

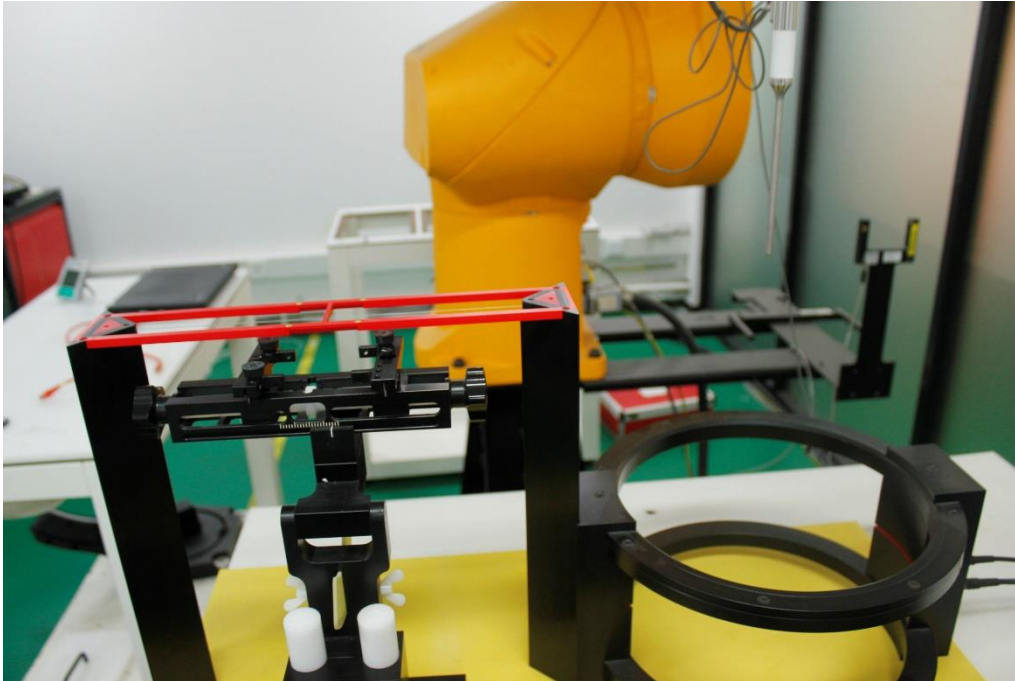
The AMMI is connected to the support device's Mic via Audio Data Line. The support device is connected to the Internet via Wi-Fi and the DUT is connected to the mobile base station via the technology under test. Using the DUT's OTT application, a VoIP call is established with the support device. The test signal is sent from the DASY PC to the AMMI, from the AMMI to the support device, and finally to the DUT. To exercise the license antenna, the DUT was simultaneously connected to an external AP and to a mobile base station.



Device1:



Device2:



Device3:



**Device4:**



Device5: The auxiliary device is pre-installed with a test version of Google duo app, The test version app can control the configurations of audio codec bitrate

Device6: The photo of DUT are presented in the additional document: Appendix to test report No.I19Z62348-SEM01/02 The photos of HAC test

**Audio Level Settings**

According to KDB 285076 D02, the average speech level of -20dBm0 shall be used for protocols not specifically listed in Table 7.1 of ANSI C63.19-2001.

Determine Input Audio level is based on the Added additional dBFS level readout by Google Duo customize application and three steps need to do.

1. Input a gain value to readout the -23dBFS level as reference. (0dBFS = 3.14 dBm0)
2. Adjust gain level to readout the dBFS level until it changes to -24dBFS.
3. Based on the step 1 and 2, and then calculate the gain value(dB) by interpolation to get the -20dBm0 corresponding gain value.

**Codec Bit-rate Investigation**

An investigation between the various bit-rate configurations (Low/Mid/High bit rates for Narrowband, Wideband, and EVS) are documented (ABM, SNNR, frequency response) to determine the worst case bit-rate for each voice service type. The tables below compare the varying bit-rate configurations

**Air Interface Investigation**

Using the worst-case bit-rate and Radio Configuration found in §11.2/11.3/11.4, a limited set of bands/channel/ bandwidths were then tested to confirm that there is no effect to the T-rating when changing the band/channel/bandwidth, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface.

## F.2.2 Codec Configuration

An investigation was performed for each applicable data mode to determine the audio codec configuration to be used for testing. The 6kbps codec setting was used for the audio codec on the auxiliary VoIP unit for OTT VoIP T-coil testing. See below tables for comparisons between codec data rates on all applicable data modes:

**Table F.2-1 Codec Investigation – OTT over EDGE**

| Codec Setting      | 64kbps | 6kbps | Orientation | Channel |
|--------------------|--------|-------|-------------|---------|
| ABM1 (dBA/m)       | 6.75   | 5.15  | Z(axial)    | 661     |
| Frequency Response | Pass   | Pass  |             |         |
| SNR (dB)           | 55.31  | 54.53 |             |         |

**Table F.2-2 Codec Investigation – OTT over HSPA**

| Codec Setting      | 64kbps | 6kbps | Orientation | Channel |
|--------------------|--------|-------|-------------|---------|
| ABM1 (dBA/m)       | 7.31   | 6.45  | Z(axial)    | 9400    |
| Frequency Response | Pass   | Pass  |             |         |
| SNR (dB)           | 50.19  | 49.81 |             |         |

**Table F.2-3 Codec Investigation – OTT over LTE**

| Codec Setting      | 64kbps | 6kbps | Orientation | Band/BW | Channel |
|--------------------|--------|-------|-------------|---------|---------|
| ABM1 (dBA/m)       | 7.83   | 8.12  | Z(axial)    | B2/20M  | 18900   |
| Frequency Response | Pass   | Pass  |             |         |         |
| SNR (dB)           | 50.12  | 49.03 |             |         |         |

**Table F.2-4 Codec Investigation – OTT over WiFi**

| Codec Setting      | 64kbps | 6kbps | Orientation | Band/BW           | Channel |
|--------------------|--------|-------|-------------|-------------------|---------|
| ABM1 (dBA/m)       | 5.29   | 7.31  | Z(axial)    | 2.4GHz<br>802.11b | 6       |
| Frequency Response | Pass   | Pass  |             |                   |         |
| SNR (dB)           | 46.54  | 46.13 |             |                   |         |

### F.2.3 Radio Configuration for OTT VoIP (LTE)

An investigation was performed to determine the modulation and RB configuration to be used for testing. 20MHz BW, QPSK, 1RB, 50RB offset was used for the testing as the worst-case configuration for the handset. See below table for comparisons between different radio configurations:

**Table F.2-5 OTT VoIP (LTE) SNR by Radio Configuration**

| Band   | Channel | Bandwidth [MHz] | Modulation | RB Size | RB Offset | ABM1 [dB(A/m)] | SNR [dB] |
|--------|---------|-----------------|------------|---------|-----------|----------------|----------|
| LTE B2 | 18900   | 20              | QPSK       | 1       | 0         | 8.90           | 50.44    |
| LTE B2 | 18900   | 20              | QPSK       | 1       | 50        | 8.12           | 49.03    |
| LTE B2 | 18900   | 20              | QPSK       | 1       | 99        | 7.78           | 50.74    |
| LTE B2 | 18900   | 20              | QPSK       | 50      | 0         | 8.55           | 50.11    |
| LTE B2 | 18900   | 20              | QPSK       | 50      | 25        | 7.63           | 49.71    |
| LTE B2 | 18900   | 20              | QPSK       | 50      | 50        | 8.51           | 49.57    |
| LTE B2 | 18900   | 20              | QPSK       | 100     | 0         | 8.39           | 50.26    |
| LTE B2 | 18900   | 20              | 16QAM      | 1       | 50        | 9.27           | 50.05    |
| LTE B2 | 18900   | 20              | 64QAM      | 1       | 50        | 9.02           | 49.49    |
| LTE B2 | 18900   | 15              | QPSK       | 1       | 50        | 8.13           | 50.51    |
| LTE B2 | 18900   | 10              | QPSK       | 1       | 50        | 7.28           | 49.42    |
| LTE B2 | 18900   | 5               | QPSK       | 1       | 50        | 9.04           | 49.86    |
| LTE B2 | 18900   | 3               | QPSK       | 1       | 50        | 8.82           | 50.28    |
| LTE B2 | 18900   | 1.4             | QPSK       | 1       | 50        | 8.91           | 50.72    |

An investigation was performed to determine the worst-case LTE band to be used for OTT VoIP testing. LTE Band 2 of FDD were used for the testing as the worst-case configuration for the handset. See below table for comparisons between different LTE bands:

**Table F.2-6 OTT VoIP (LTE) SNR by LTE bands**

| Band    | Channel | Bandwidth [MHz] | Modulation | RB Size | RB Offset | ABM1 [dB(A/m)] | SNR [dB] |
|---------|---------|-----------------|------------|---------|-----------|----------------|----------|
| LTE B2  | 21100   | 20              | QPSK       | 1       | 50        | 8.12           | 49.03    |
| LTE B4  | 20175   | 20              | QPSK       | 1       | 50        | 7.48           | 48.15    |
| LTE B5  | 20525   | 10              | QPSK       | 1       | 50        | 8.15           | 49.85    |
| LTE B12 | 23095   | 10              | QPSK       | 1       | 50        | 7.72           | 50.11    |
| LTE B14 | 23330   | 10              | QPSK       | 1       | 50        | 8.96           | 49.57    |
| LTE B30 | 27710   | 10              | QPSK       | 1       | 50        | 8.29           | 49.84    |

## F.2.4 Radio Configuration for OTT VoIP (WiFi)

An investigation was performed on all applicable data rates and modulations to determine the radio configuration to be used for testing. See below tables for comparisons between different radio configurations in each 802.11 standard:

**Table F.2-7 802.11b SNR by Radio Configuration**

| Mode    | Channel | Modulation | Data Rate [Mbps] | ABM1 [dB(A/m)] | SNR [dB] |
|---------|---------|------------|------------------|----------------|----------|
| 802.11b | 6       | DSSS       | 1                | 7.31           | 46.13    |
| 802.11b | 6       | DSSS       | 2                | 6.05           | 45.91    |
| 802.11b | 6       | CCK        | 5.5              | 6.29           | 46.37    |
| 802.11b | 6       | CCK        | 11               | 7.17           | 46.48    |

**Table F.2-8 802.11g SNR by Radio Configuration**

| Mode    | Channel | Modulation | Data Rate [Mbps] | ABM1 [dB(A/m)] | SNR [dB] |
|---------|---------|------------|------------------|----------------|----------|
| 802.11g | 6       | BPSK       | 6                | 6.47           | 47.21    |
| 802.11g | 6       | BPSK       | 9                | 7.93           | 47.14    |
| 802.11g | 6       | QPSK       | 12               | 7.70           | 46.60    |
| 802.11g | 6       | QPSK       | 18               | 6.89           | 47.35    |
| 802.11g | 6       | 16-QAM     | 24               | 7.88           | 47.46    |
| 802.11g | 6       | 16-QAM     | 36               | 6.99           | 47.41    |
| 802.11g | 6       | 64-QAM     | 48               | 6.76           | 47.86    |
| 802.11g | 6       | 64-QAM     | 54               | 7.74           | 46.75    |

**Table F.2-9 802.11n 20MHz BW SNR by Radio Configuration**

| Mode    | Bandwidth [MHz] | Channel | Modulation | Data Rate [Mbps] | ABM1 [dB(A/m)] | SNR [dB] |
|---------|-----------------|---------|------------|------------------|----------------|----------|
| 802.11n | 20              | 6       | BPSK       | 6.5              | 7.67           | 47.88    |
| 802.11n | 20              | 6       | QPSK       | 13               | 7.71           | 47.13    |
| 802.11n | 20              | 6       | QPSK       | 19.5             | 7.15           | 47.16    |
| 802.11n | 20              | 6       | 16-QAM     | 26               | 6.74           | 47.39    |
| 802.11n | 20              | 6       | 16-QAM     | 39               | 7.62           | 47.64    |
| 802.11n | 20              | 6       | 64-QAM     | 52               | 6.96           | 47.85    |
| 802.11n | 20              | 6       | 64-QAM     | 58.5             | 6.46           | 47.17    |
| 802.11n | 20              | 6       | 64-QAM     | 65               | 8.07           | 47.11    |

## F.2.5 Test results for OTT VoIP

**Table F.2-10 Test results for 2/3G**

| Probe Position | Band          | Ch.  | Measurement Position (x mm, y mm) | ABM1 (dB A/m) | SNR (dB) | Category T ? |
|----------------|---------------|------|-----------------------------------|---------------|----------|--------------|
| Transverse     | EDGE850(2TX)  | 190  | 1.2,8.4                           | -2.31         | 50.16    | T4           |
|                | EDGE1900(2TX) | 661  | 0.8,14.6                          | -1.11         | 49.98    | T4           |
|                | W850          | 4407 | 0.2,-3.9                          | -0.98         | 52.18    | T4           |
|                | W1900         | 9800 | 0.8, -4.2                         | -1.45         | 53.27    | T4           |
|                | W1700         | 1637 | -4.2,-4.2                         | -1.08         | 49.21    | T4           |
| Perpendicular  | EDGE850(2TX)  | 190  | -0.9,7.1                          | 5.34          | 52.31    | T4           |
|                | EDGE1900(2TX) | 661  | -0.4,6.2                          | 5.15          | 54.53    | T4           |
|                | W850          | 4407 | -1.1,5.6                          | 4.31          | 50.26    | T4           |
|                | W1900         | 9800 | -0.4,7.1                          | 6.45          | 49.81    | T4           |
|                | W1700         | 1637 | -1.2,4.6                          | 6.74          | 49.10    | T4           |

Note:

1. Bluetooth and WiFi function is turn off and microphone is muted.
2. Signal strength measurement scan plots are presented in Annex B.
3. The volume is adjusted to maximum level during T-Coil testing.

**Table F.2-11 Test results for LTE**

| Probe Position | Band   | Ch.   | Band width | Measurement Position (x mm, y mm) | ABM1 (dB A/m) | SNR (dB) | Category T ? |
|----------------|--------|-------|------------|-----------------------------------|---------------|----------|--------------|
| Transverse     | LTE B4 | 20175 | 20         | -7.5,-4.2                         | -6.45         | 42.76    | T4           |
| Perpendicular  | LTE B4 | 20175 | 20         | 0,8.3                             | 7.48          | 48.15    | T4           |

Note:

1. Bluetooth and WiFi function is turn off and microphone is muted.
2. The worse case of each band for signal strength measurement scan plots are presented in Annex B.
3. The volume is adjusted to maximum level during T-Coil testing.

**Table F.2-12 Test results for WiFi**

| Probe Position | Mode    | Ch. | Bandwidth | Measurement Position (x mm, y mm) | ABM1 (dB A/m) | SNR (dB) | Category T ? |
|----------------|---------|-----|-----------|-----------------------------------|---------------|----------|--------------|
| Transverse     | 802.11b | 6   | 20M       | -5,9.2                            | -1.07         | 39.69    | T4           |
|                | 802.11g | 6   | 20M       | -4.2,8.7                          | -2.11         | 40.47    | T4           |
|                | 802.11n | 6   | 20M       | -3.6,9.1                          | -1.31         | 40.23    | T4           |
| Perpendicular  | 802.11b | 6   | 20M       | -4.2,5                            | 6.05          | 45.91    | T4           |
|                | 802.11g | 6   | 20M       | 0.4,4.6                           | 7.70          | 46.60    | T4           |
|                | 802.11n | 6   | 20M       | -2.7,4.1                          | 8.07          | 47.11    | T4           |

Note:

1. Bluetooth and WiFi function is turn off and microphone is muted.
2. The worse case of each mode for signal strength measurement scan plots are presented in Annex B.
3. The volume is adjusted to maximum level during T-Coil testing.

### F.3 Test plots of spot check

#### T-Coil GSM 850 Transverse

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: GSM 850; Frequency: 836.6 MHz; Duty Cycle: 1:8.3

Probe: AM1DV2 - 1064;

#### T-Coil/General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated

Signal(x, y, z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

#### Cursor:

ABM1 = -0.06 dBA/m

BWC Factor = 0.16 dB

Location: 3.8, 12.9, 3.7 mm

#### T-Coil/General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated

SNR(x, y, z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

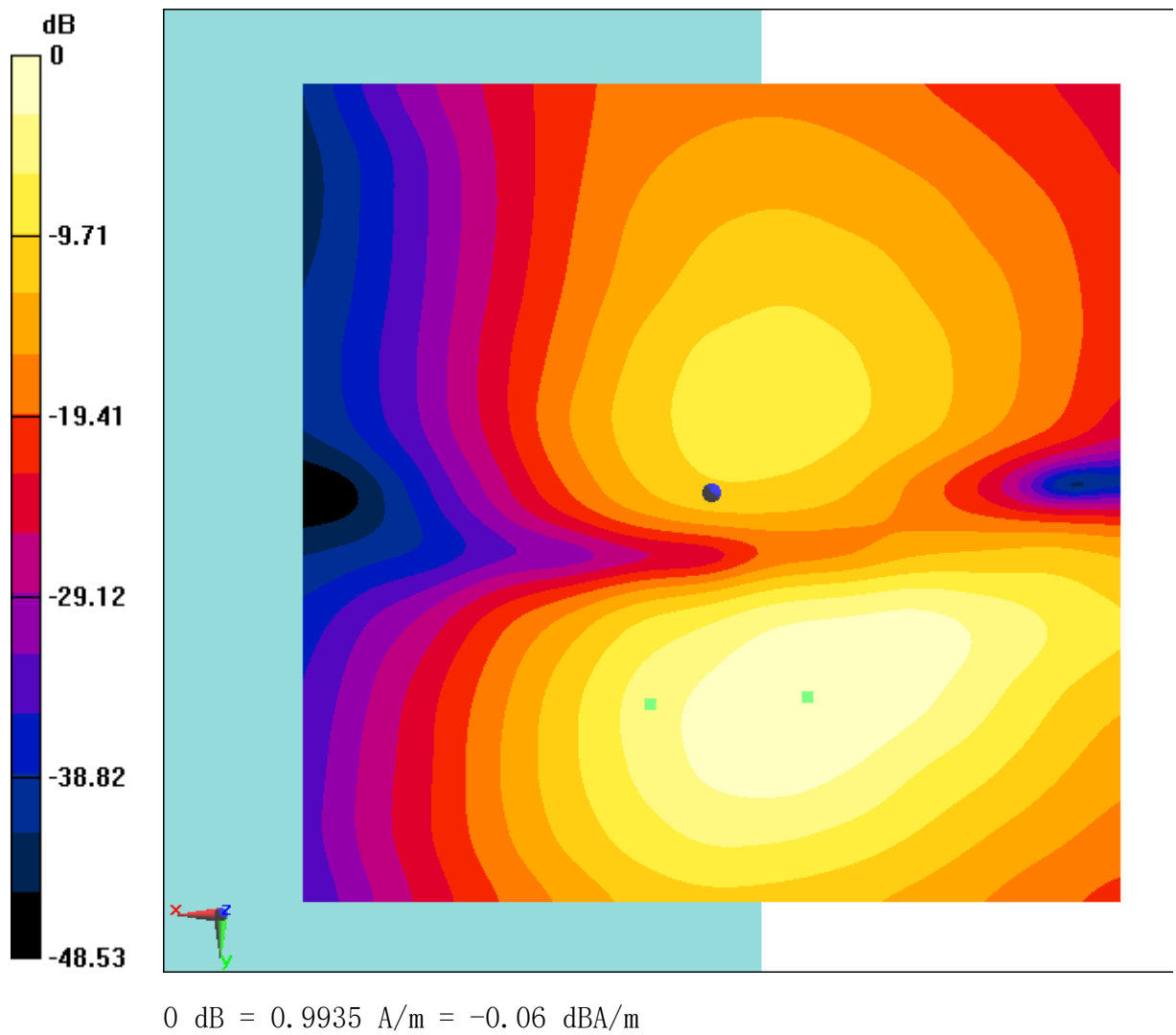
#### Cursor:

ABM1/ABM2 = 42.16 dB

ABM1 comp = -4.19 dBA/m

BWC Factor = 0.16 dB

Location: -5.8, 12.5, 3.7 mm



**Fig F.3.1 T-Coil GSM 850**



### **T-Coil GSM 850 Perpendicular**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: GSM 850; Frequency: 836.6 MHz; Duty Cycle: 1:8.3

Probe: AM1DV2 - 1064;

### **T-Coil/General Scans/z (axial) 4.2mm 50 x 50 12.2kbps/ABM Interpolated**

**Signal(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

#### **Cursor:**

ABM1 = 7.55 dBA/m

BWC Factor = 0.16 dB

Location: 3.8, 4.2, 3.7 mm

### **T-Coil/General Scans/z (axial) 4.2mm 50 x 50 12.2kbps/ABM Interpolated**

**SNR(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

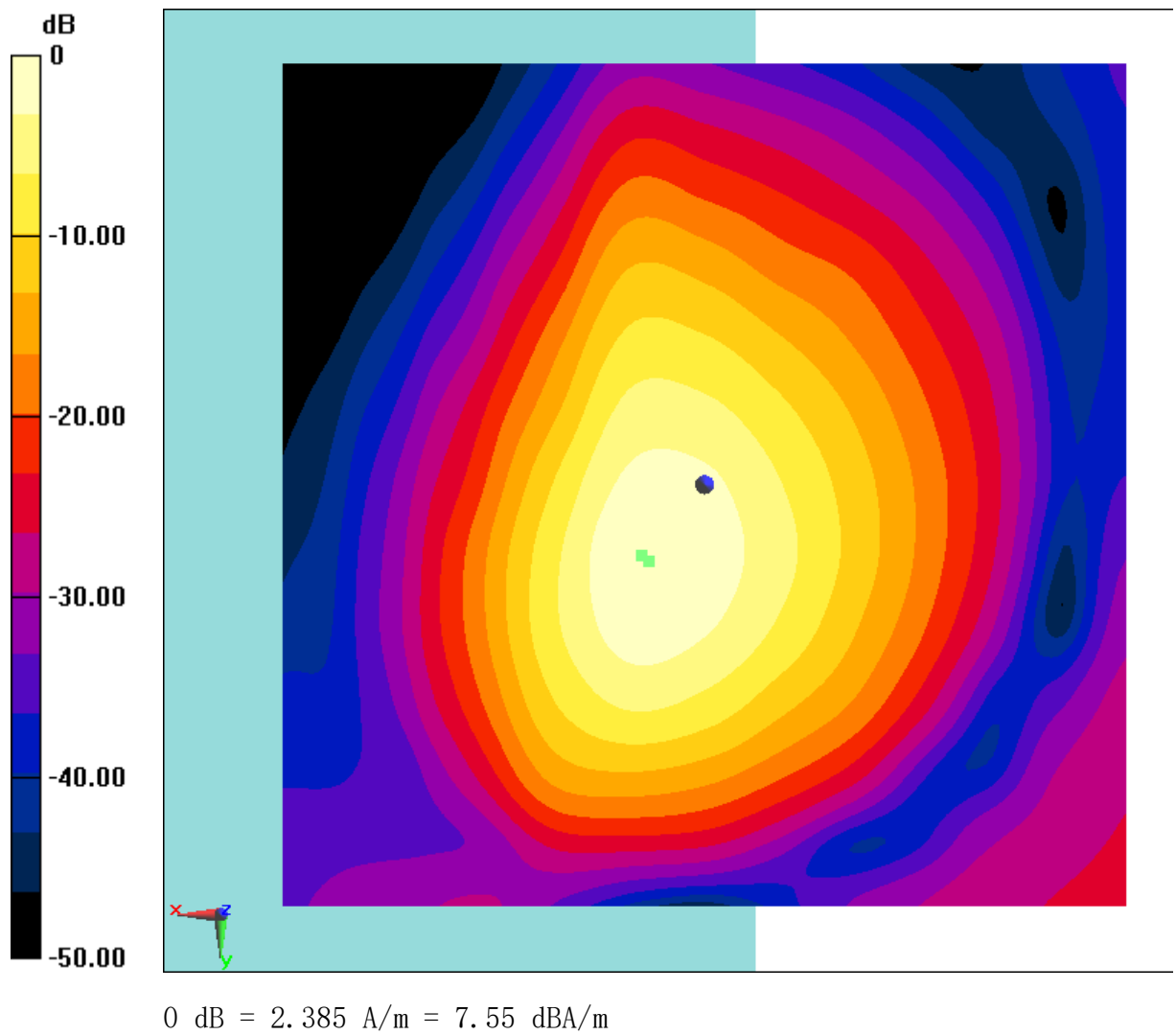
#### **Cursor:**

ABM1/ABM2 = 42.93 dB

ABM1 comp = 7.47 dBA/m

BWC Factor = 0.16 dB

Location: 3.3, 4.6, 3.7 mm



**Fig F.3.2 T-Coil GSM 850**



### **T-Coil WCDMA 1900 Transverse**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: WCDMA 1900; Frequency: 1880 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

### **T-Coil/General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated**

**Signal(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

#### **Cursor:**

ABM1 = -0.29 dBA/m

BWC Factor = 0.16 dB

Location: 3.3, 12.9, 3.7 mm

### **T-Coil/General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated**

**SNR(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

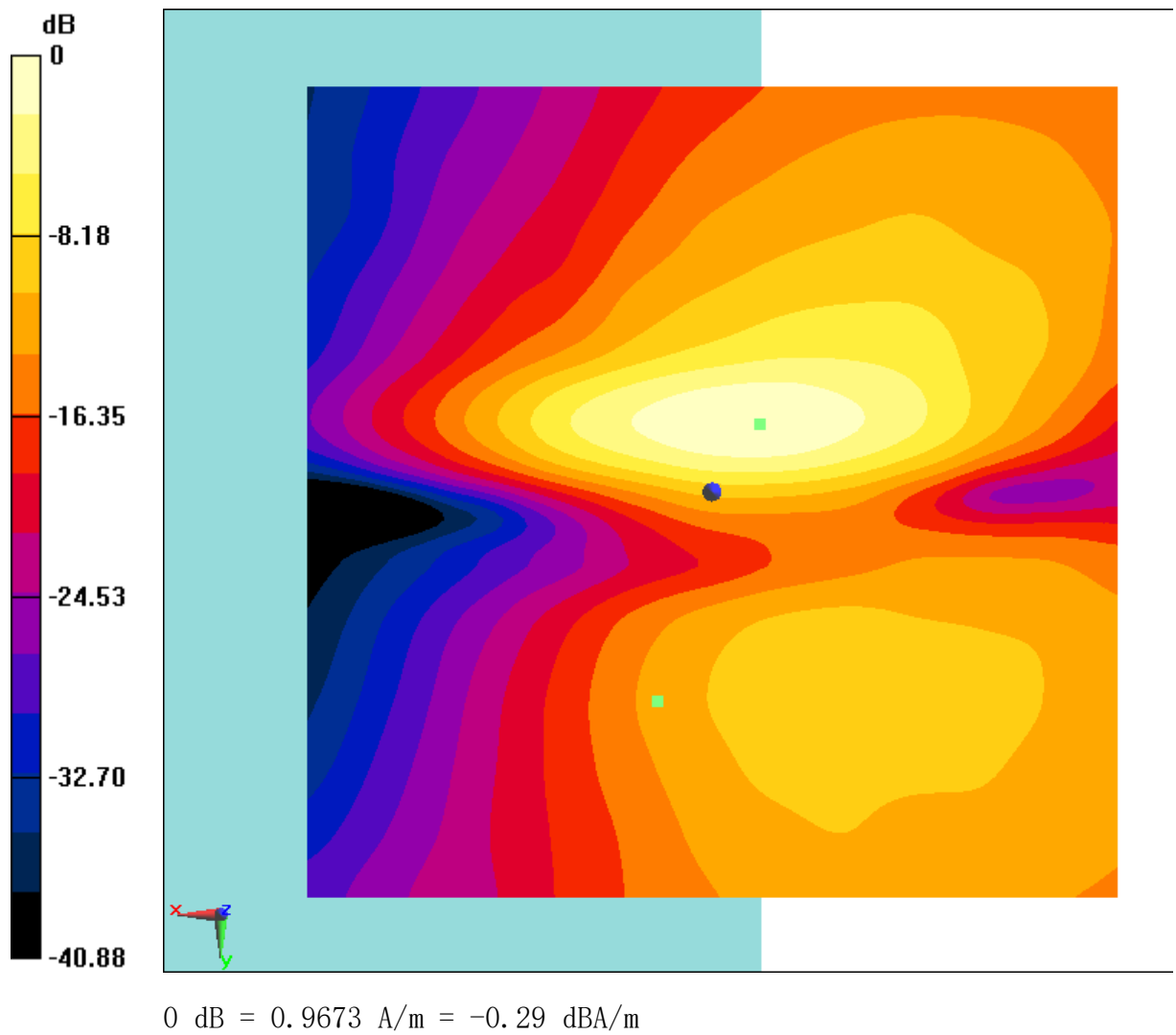
#### **Cursor:**

ABM1/ABM2 = 49.97 dB

ABM1 comp = -5.41 dBA/m

BWC Factor = 0.16 dB

Location: -2.9, -4.2, 3.7 mm



**Fig F.3.3 T-Coil WCDMA 1900**



### **T-Coil WCDMA 1900 Perpendicular**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: WCDMA 1900; Frequency: 1880 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

### **T-Coil/General Scans/z (axial) 4.2mm 50 x 50 12.2kbps/ABM Interpolated**

**Signal(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

#### **Cursor:**

ABM1 = 7.30 dBA/m

BWC Factor = 0.16 dB

Location: 3.8, 3.3, 3.7 mm

### **T-Coil/General Scans/z (axial) 4.2mm 50 x 50 12.2kbps/ABM Interpolated**

**SNR(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

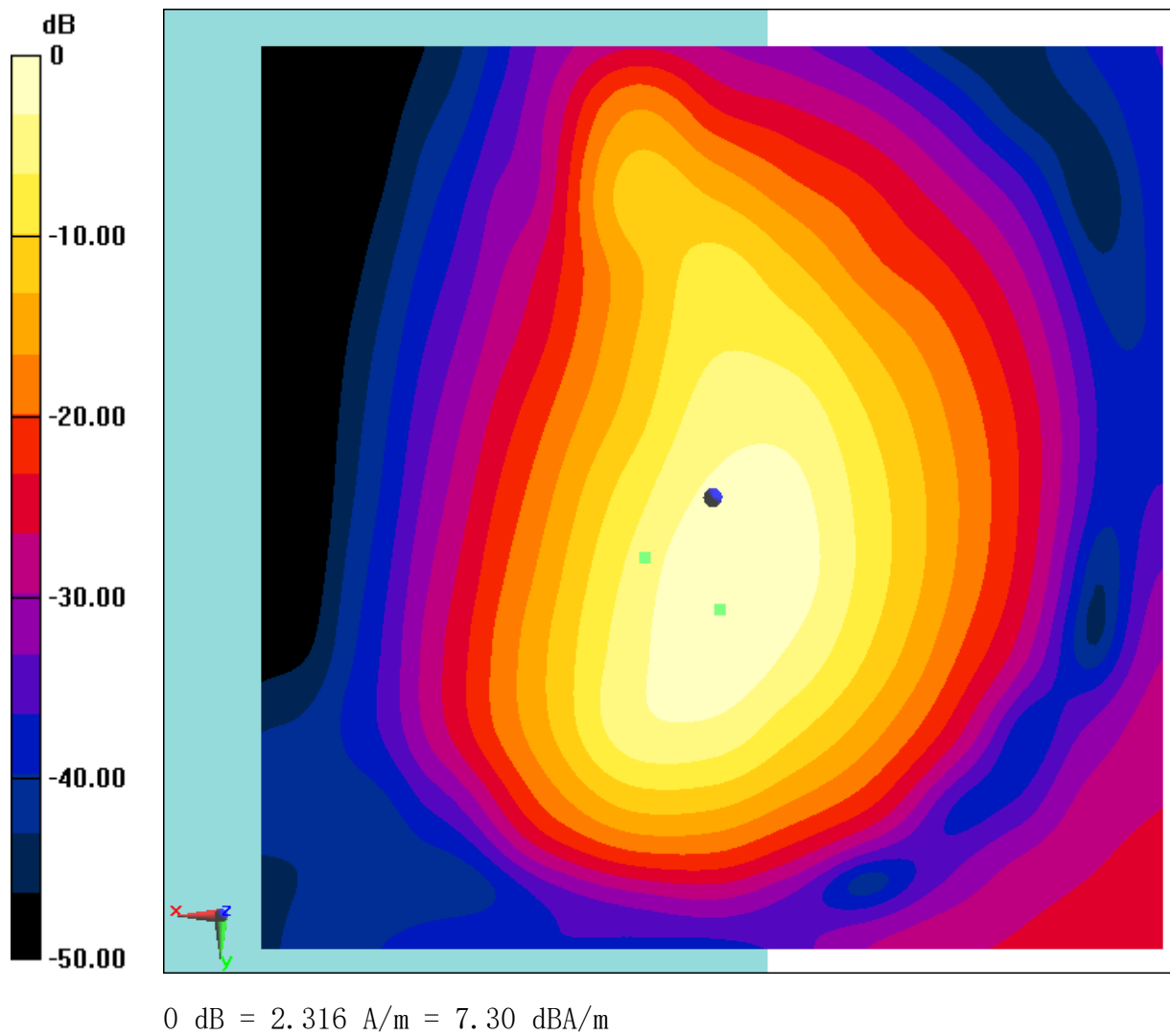
#### **Cursor:**

ABM1/ABM2 = 51.83 dB

ABM1 comp = 5.39 dBA/m

BWC Factor = 0.16 dB

Location: -0.4, 6.2, 3.7 mm



**Fig F.3.4 T-Coil WCDMA 1900**



**T-Coil LTE B4 20M Transverse**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: LTE B4; Frequency: 1732.5 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

T-Coil/General Scans/y (transversal) 4.2mm 50 x 50 20M/ABM

Interpolated Signal(x, y, z) (121x121x1): Interpolated grid: dx=1.000 mm,

dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

**Cursor:**

ABM1 = -0.43 dBA/m

BWC Factor = 0.16 dB

Location: 2.9, 12.5, 3.7 mm

T-Coil/General Scans/y (transversal) 4.2mm 50 x 50 20M/ABM

Interpolated SNR(x, y, z) (121x121x1): Interpolated grid: dx=1.000 mm,

dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

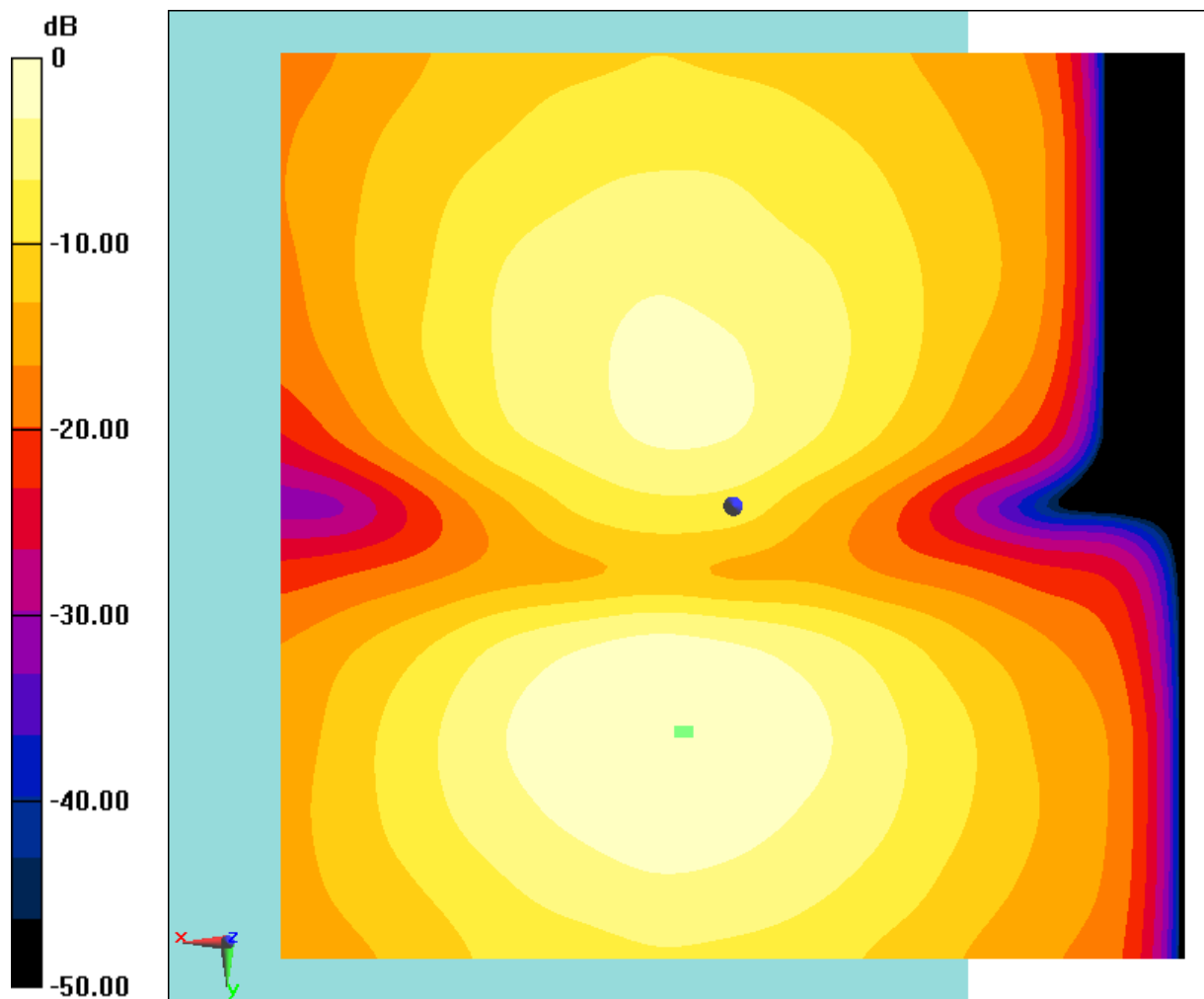
**Cursor:**

ABM1/ABM2 = 59.06 dB

ABM1 comp = -0.44 dBA/m

BWC Factor = 0.16 dB

Location: 2.5, 12.5, 3.7 mm



0 dB = 0.9519 A/m = -0.43 dBA/m

**Fig F.3.5 T-Coil LTE B4**



**T-Coil LTE B2 20M Perpendicular**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: LTE B2; Frequency: 1880 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

**T-Coil/General Scans/z (axial) 4.2mm 50 x 50 20M/ABM Interpolated**

**Signal(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

**Cursor:**

ABM1 = 7.45 dBA/m

BWC Factor = 0.16 dB

Location: 3.3, 2.9, 3.7 mm

**T-Coil/General Scans/z (axial) 4.2mm 50 x 50 20M/ABM Interpolated**

**SNR(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

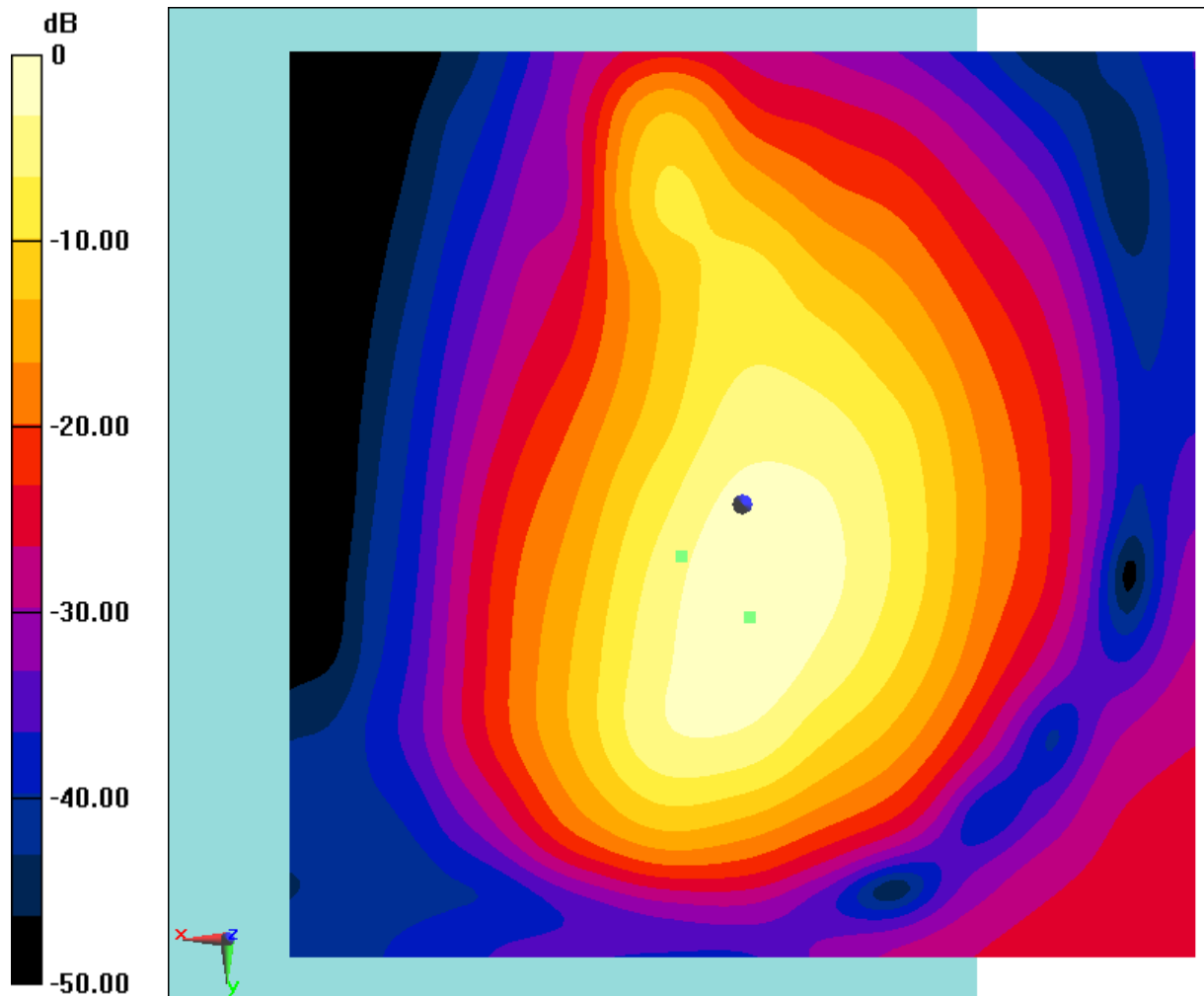
**Cursor:**

ABM1/ABM2 = 46.48 dB

ABM1 comp = 5.47 dBA/m

BWC Factor = 0.16 dB

Location: -0.4, 6.2, 3.7 mm



0 dB = 2.358 A/m = 7.45 dBA/m

**Fig F.3.6 T-Coil LTE B2**

**T-Coil WiFi-2.4G 11n Transverse**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: WiFi-2.4G; Frequency: 2437 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

y (transversal) 4.2mm 50 x 50/ABM Interpolated Signal(x, y, z)

(121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

**Cursor:**

ABM1 = 1.97 dBA/m

BWC Factor = 0.16 dB

Location: 3.3, 12.1, 3.7 mm

y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x, y, z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

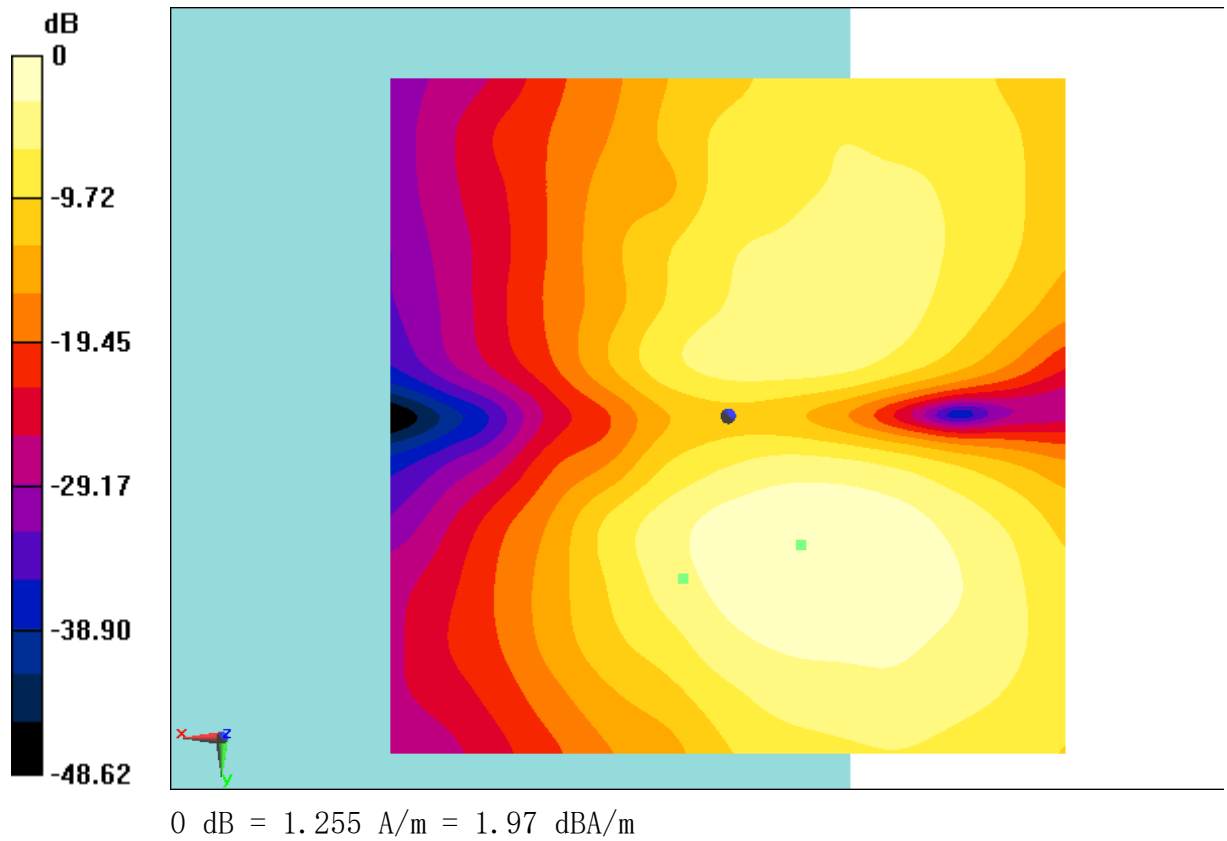
**Cursor:**

ABM1/ABM2 = 42.76 dB

ABM1 comp = -2.01 dBA/m

BWC Factor = 0.16 dB

Location: -5.5, 9.7, 3.7 mm



**Fig F.3.7 T-Coil WiFi-2. 4G**

**T-Coil WiFi-2.4G 11n Perpendicular**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: WiFi-2.4G; Frequency: 2437 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

**z (axial) 4.2mm 50 x 50/ABM Interpolated Signal(x, y, z) (121x121x1):**

Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

**Cursor:**

ABM1 = 9.91 dBA/m

BWC Factor = 0.16 dB

Location: 4.2, 0.8, 3.7 mm

**z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x, y, z) (121x121x1):**

Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

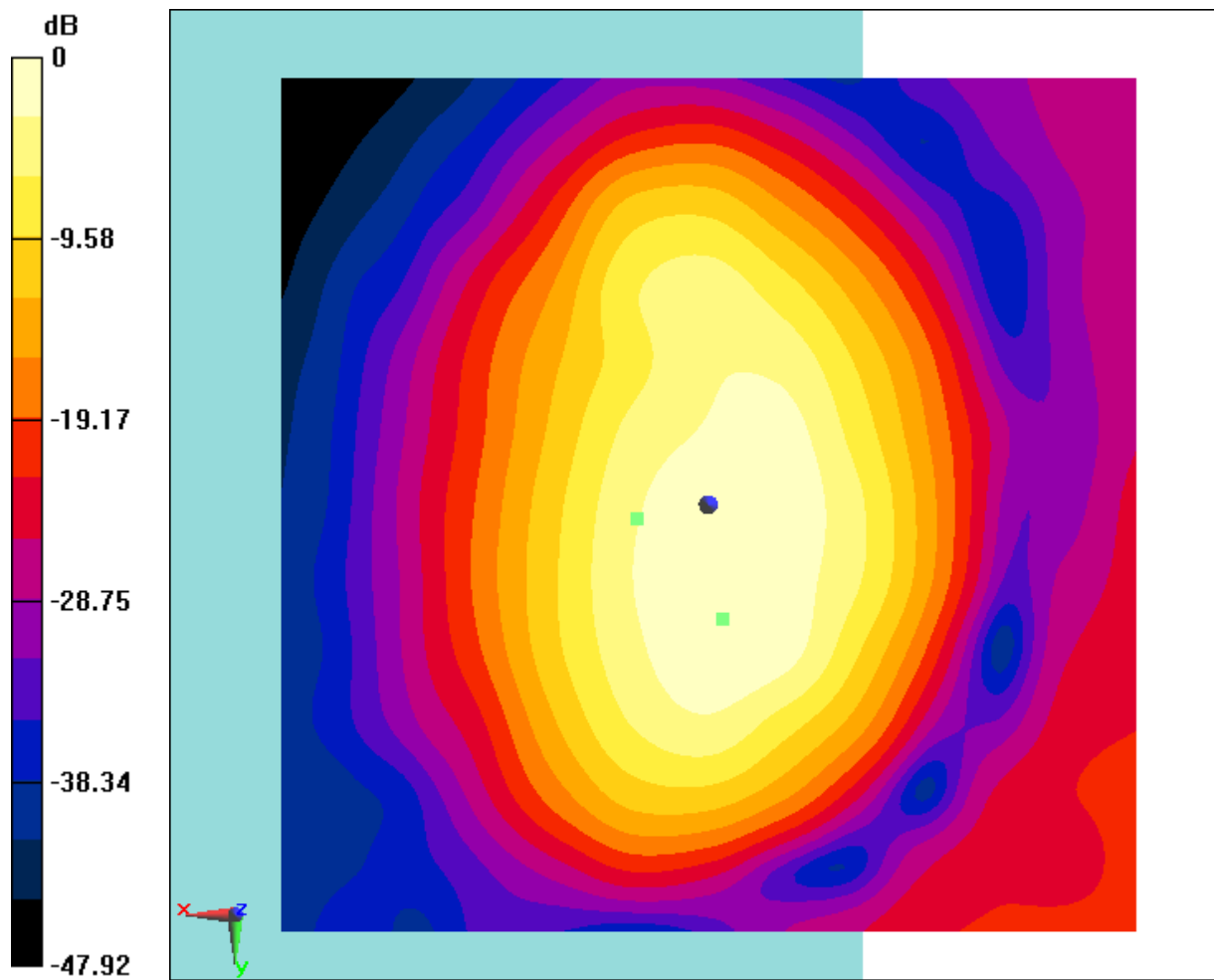
**Cursor:**

ABM1/ABM2 = 46.57 dB

ABM1 comp = 5.65 dBA/m

BWC Factor = 0.16 dB

Location: -0.9, 6.6, 3.7 mm



0 dB = 3.130 A/m = 9.91 dBA/m

**Fig F.3.8 T-Coil WiFi-2.4G**

#### F.4 Test plots of Google duo

##### T-Coil WCDMA 1700 Transverse

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: WCDMA 1700; Frequency: 1732.4 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

##### T-Coil/General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated

Signal(x, y, z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

##### Cursor:

ABM1 = 4.19 dBA/m

BWC Factor = 0.16 dB

Location: 3.8, 13.3, 3.7 mm

##### T-Coil/General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated

SNR(x, y, z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

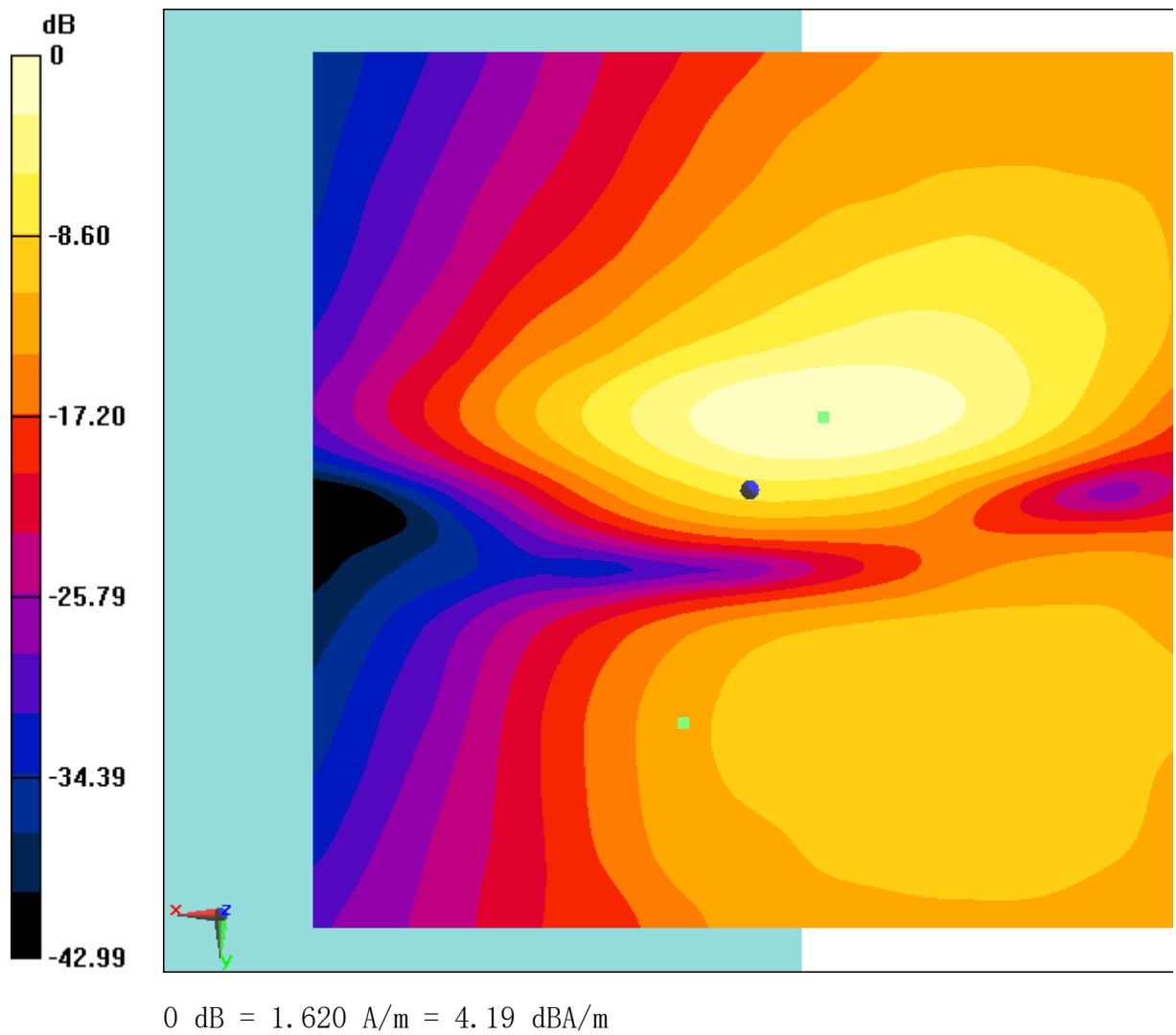
##### Cursor:

ABM1/ABM2 = 49.21 dB

ABM1 comp = -1.08 dBA/m

BWC Factor = 0.16 dB

Location: -4.2, -4.2, 3.7 mm



**Fig F.4.1 T-Coil WCDMA 1700**



### **T-Coil WCDMA 1700 Perpendicular**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: WCDMA 1700; Frequency: 1732.4 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

### **T-Coil/General Scans/z (axial) 4.2mm 50 x 50 4.75kbps/ABM Interpolated**

**Signal(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

#### **Cursor:**

ABM1 = 8.13 dBA/m

BWC Factor = 0.16 dB

Location: 2.5, 3.3, 3.7 mm

### **T-Coil/General Scans/z (axial) 4.2mm 50 x 50 4.75kbps/ABM Interpolated**

**SNR(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 37.15

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

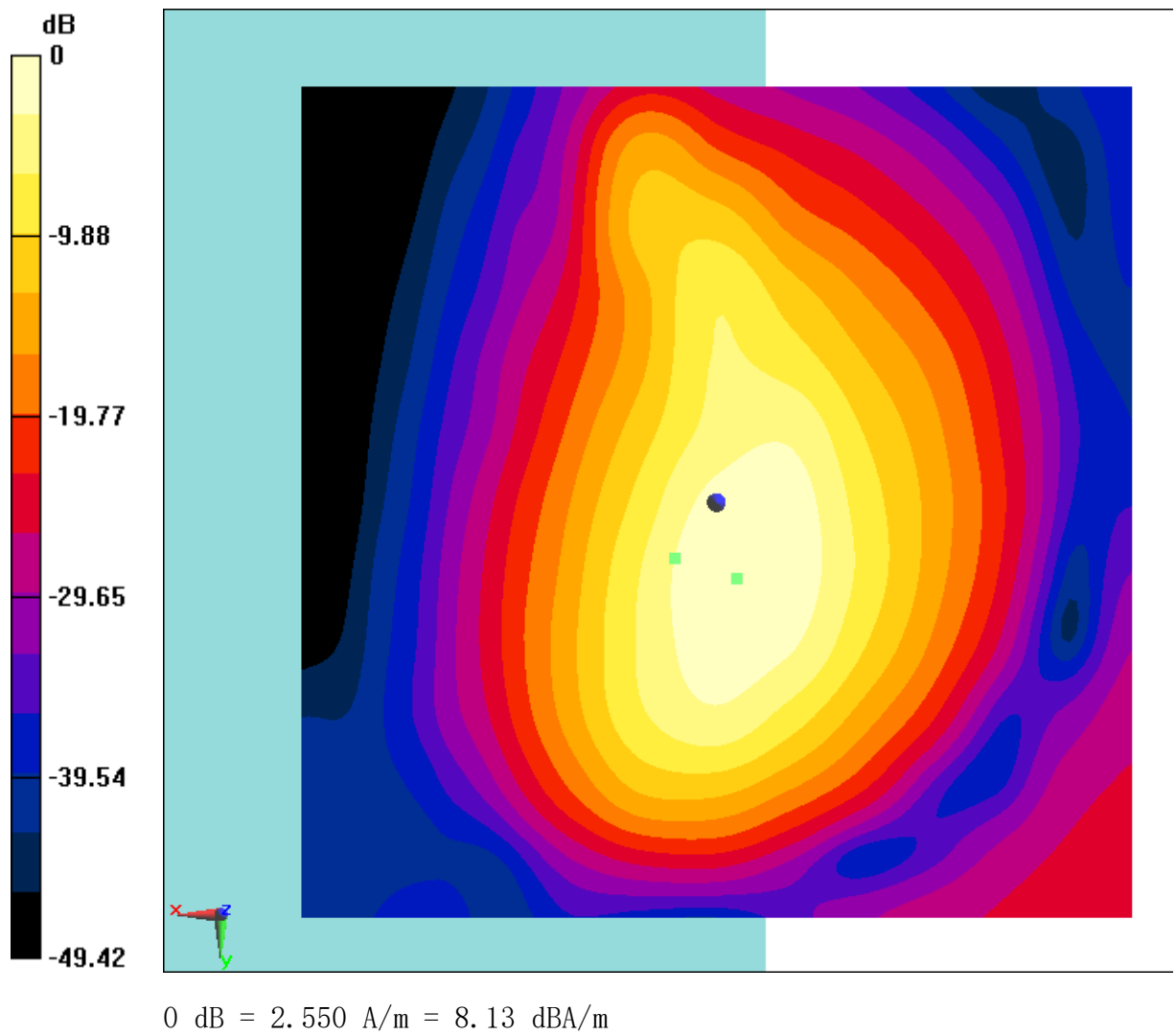
#### **Cursor:**

ABM1/ABM2 = 49.10 dB

ABM1 comp = 6.74 dBA/m

BWC Factor = 0.16 dB

Location: -1.2, 4.6, 3.7 mm



**Fig F.4.2 T-Coil WCDMA 1700**



**T-Coil LTE B4 20M Transverse**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: LTE B4; Frequency: 1732.5 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

T-Coil/General Scans/y (transversal) 4.2mm 50 x 50 20M/ABM

Interpolated Signal(x, y, z) (121x121x1): Interpolated grid: dx=1.000 mm,

dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

**Cursor:**

ABM1 = 1.69 dBA/m

BWC Factor = 0.16 dB

Location: 0.4, 13.7, 3.7 mm

T-Coil/General Scans/y (transversal) 4.2mm 50 x 50 20M/ABM

Interpolated SNR(x, y, z) (121x121x1): Interpolated grid: dx=1.000 mm,

dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

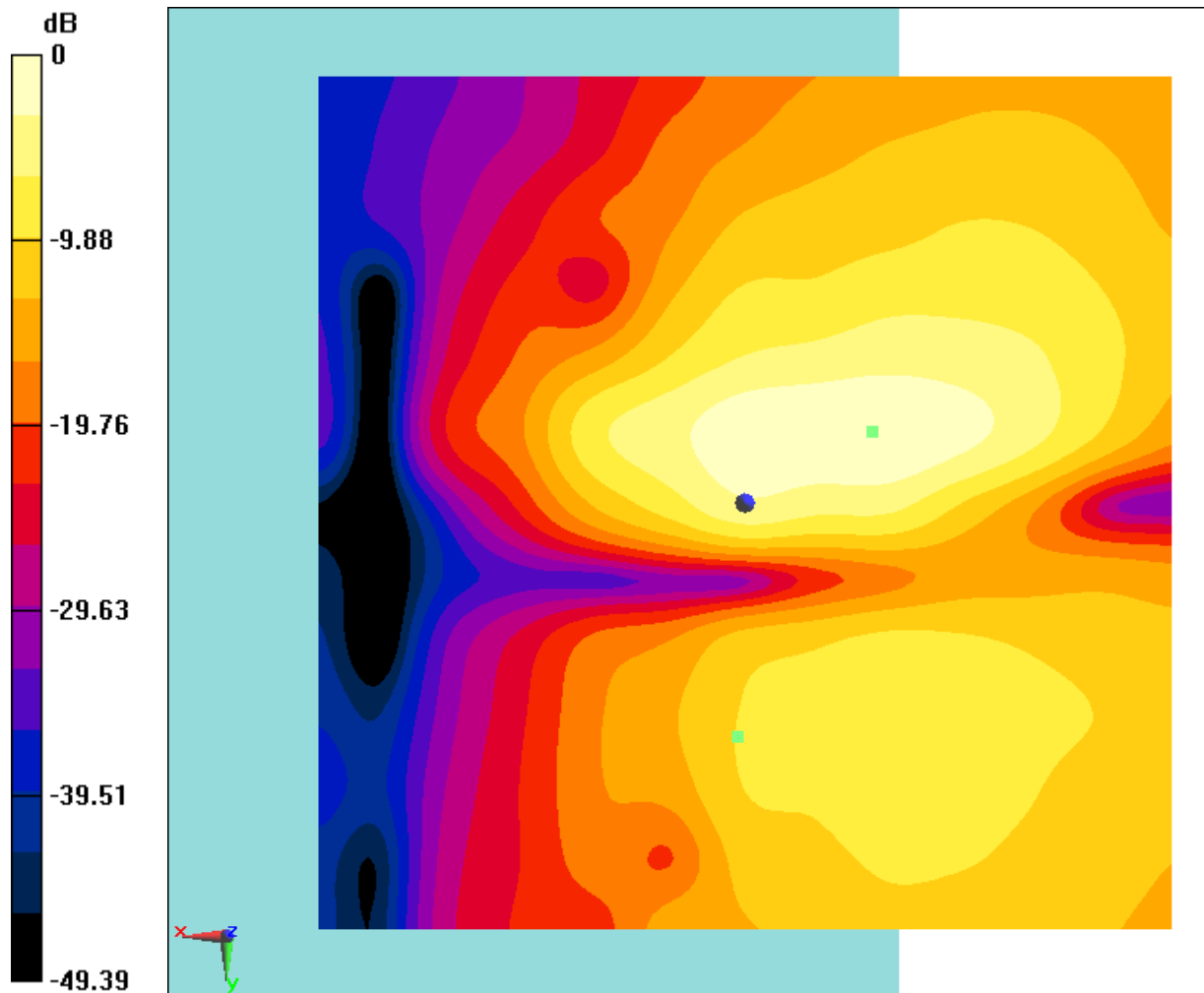
**Cursor:**

ABM1/ABM2 = 42.76 dB

ABM1 comp = -6.45 dBA/m

BWC Factor = 0.16 dB

Location: -7.5, -4.2, 3.7 mm



0 dB = 1.215 A/m = 1.69 dBA/m

**Fig F.4.3 T-Coil LTE B4**



**T-Coil LTE B4 10M Perpendicular**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: LTE B4; Frequency: 1732.5 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

**T-Coil/General Scans/z (axial) 4.2mm 50 x 50 20M/ABM Interpolated**

**Signal(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

**Cursor:**

ABM1 = 10.36 dBA/m

BWC Factor = 0.16 dB

Location: 3.3, 4.2, 3.7 mm

**T-Coil/General Scans/z (axial) 4.2mm 50 x 50 20M/ABM Interpolated**

**SNR(x, y, z) (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

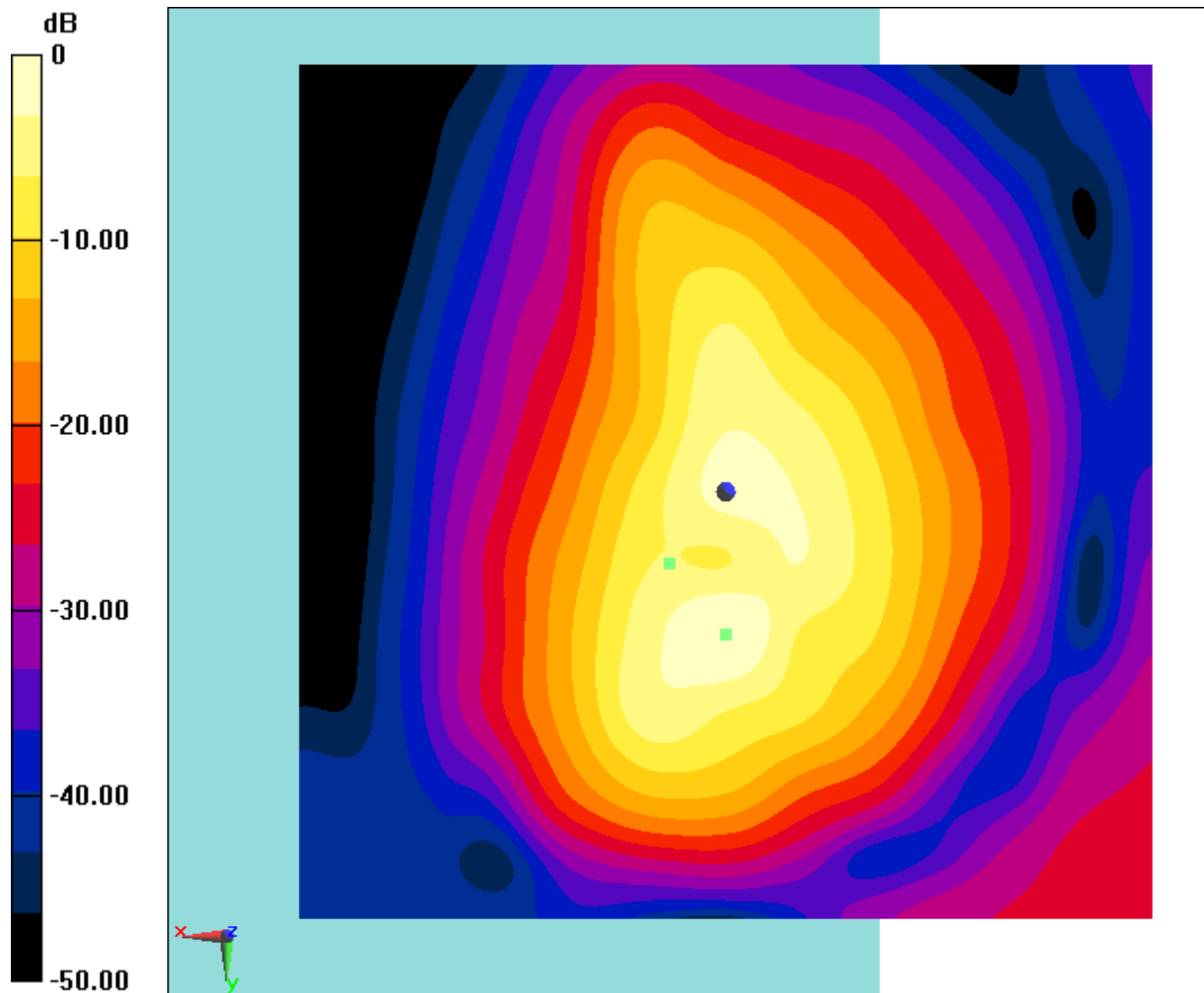
**Cursor:**

ABM1/ABM2 = 48.15 dB

ABM1 comp = 7.48 dBA/m

BWC Factor = 0.16 dB

Location: 0, 8.3, 3.7 mm



0 dB = 3.297 A/m = 10.36 dBA/m

**Fig F.4.4 T-Coil LTE B4**



**T-Coil WiFi-2.4G 11b Transverse**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: WiFi-2.4G; Frequency: 2437 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

y (transversal) 4.2mm 50 x 50/ABM Interpolated Signal(x, y, z)

(121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

**Cursor:**

ABM1 = 1.19 dBA/m

BWC Factor = 0.16 dB

Location: 4.6, 10.8, 3.7 mm

y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x, y, z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

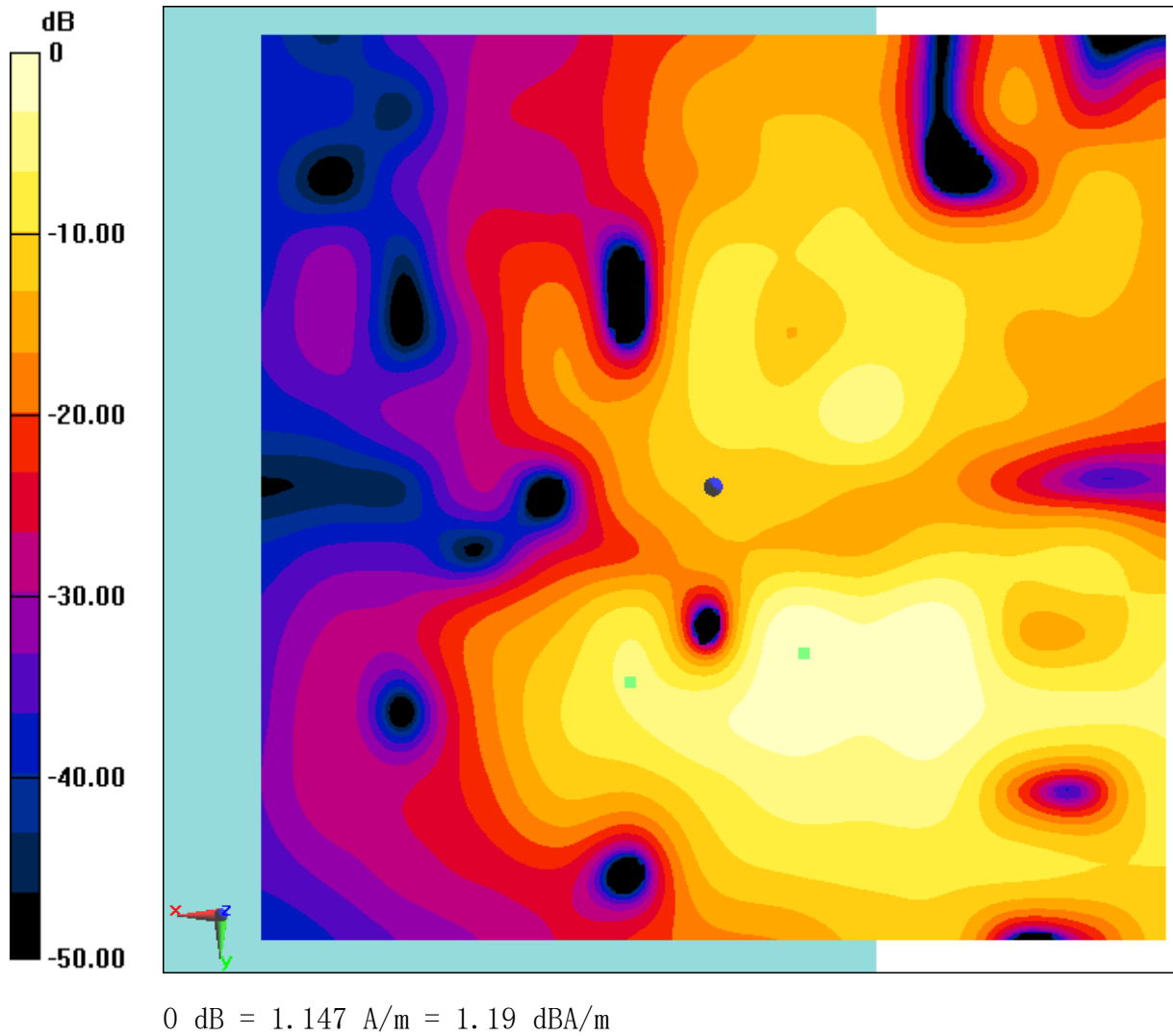
**Cursor:**

ABM1/ABM2 = 39.69 dB

ABM1 comp = -1.07 dBA/m

BWC Factor = 0.16 dB

Location: -5, 9.2, 3.7 mm



**Fig F.4.5 T-Coil WiFi-2. 4G**



**T-Coil WiFi-2.4G 11b Perpendicular**

Date: 2020-1-15

Electronics: DAE4 Sn1331

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Ambient Temperature: 22.5°C

Communication System: WiFi-2.4G; Frequency: 2437 MHz; Duty Cycle: 1:1

Probe: AM1DV2 - 1064;

**z (axial) 4.2mm 50 x 50/ABM Interpolated Signal(x, y, z) (121x121x1):**

Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

**Cursor:**

ABM1 = 9.08 dBA/m

BWC Factor = 0.16 dB

Location: 4.6, 4.2, 3.7 mm

**z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x, y, z) (121x121x1):**

Interpolated grid: dx=1.000 mm, dy=1.000 mm

Signal Type: Audio File (.wav) 48k\_voice\_1kHz\_1s.wav

Output Gain: 100

Measure Window Start: 300ms

Measure Window Length: 1000ms

BWC applied: 0.16 dB

Device Reference Point: 0, 0, -6.3 mm

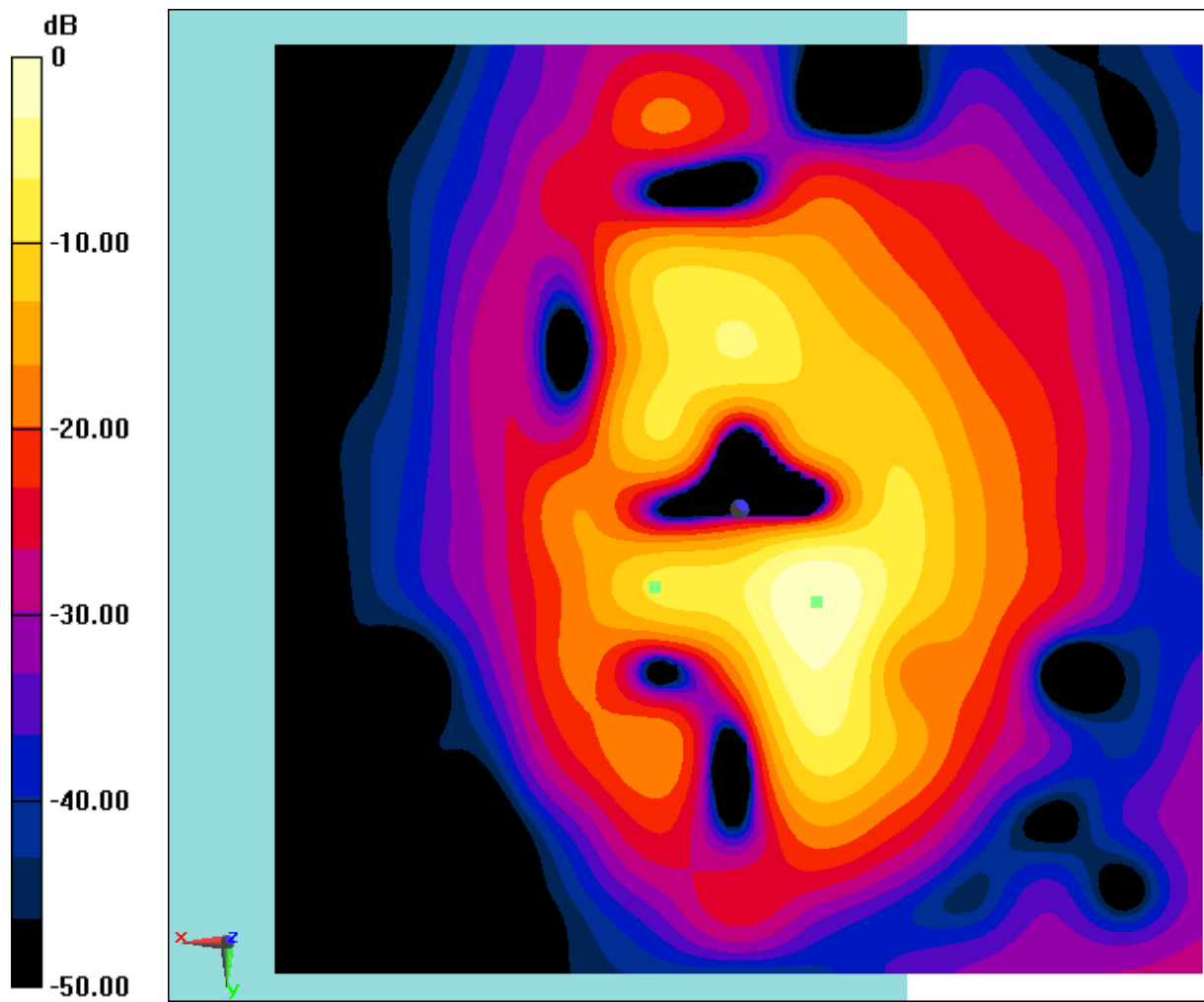
**Cursor:**

ABM1/ABM2 = 45.91 dB

ABM1 comp = 6.05 dBA/m

BWC Factor = 0.16 dB

Location: -4.2, 5, 3.7 mm



0 dB = 2.846 A/m = 9.08 dBA/m

**Fig F.4.6 T-Coil WiFi-2.4G**

## F.5 Frequency respond curves of spot check

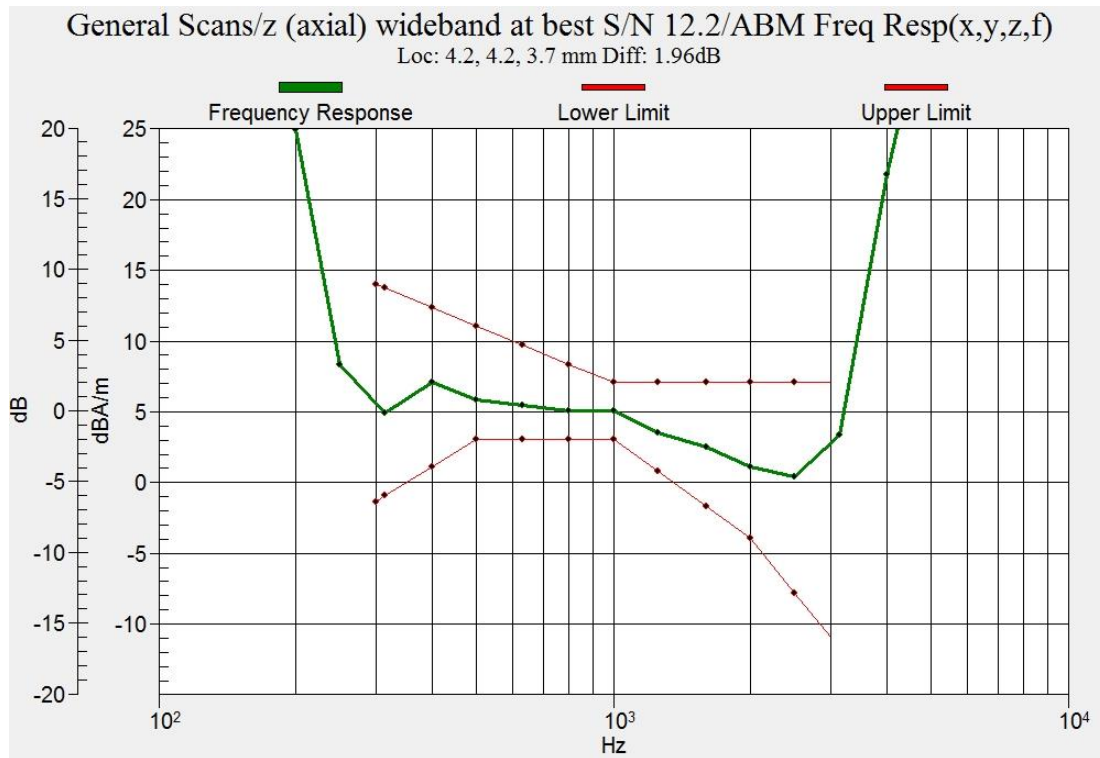


Figure F.5.1 Frequency Response of GSM 850

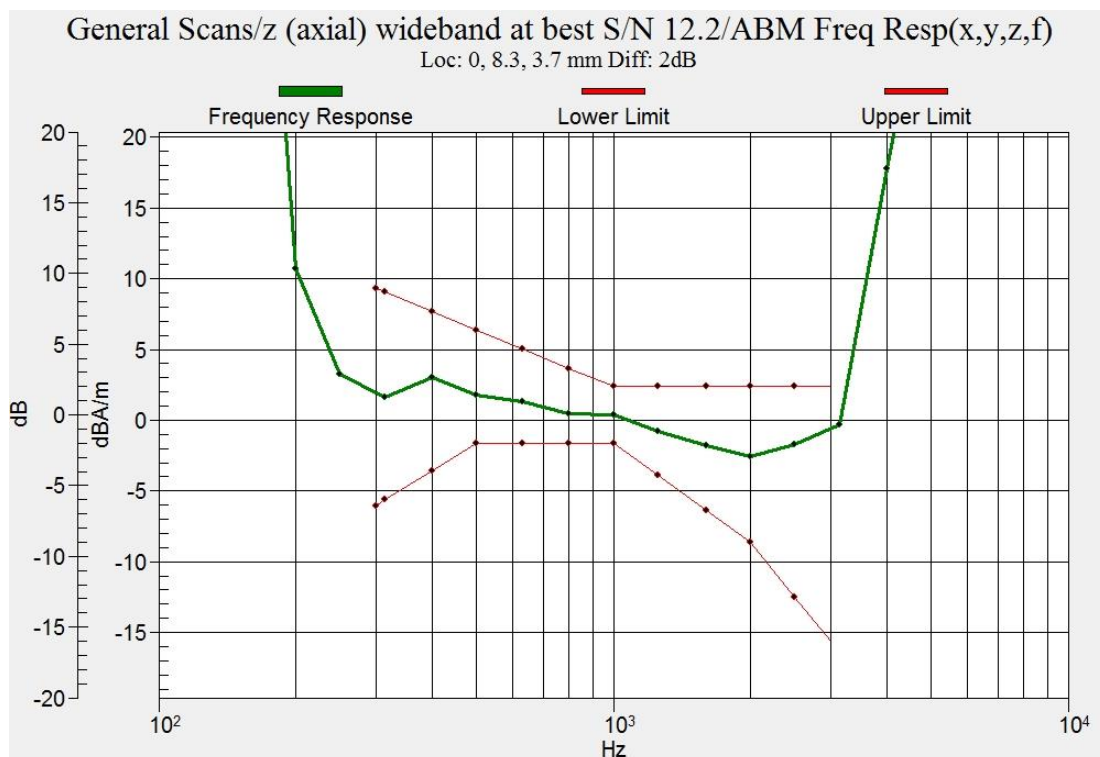
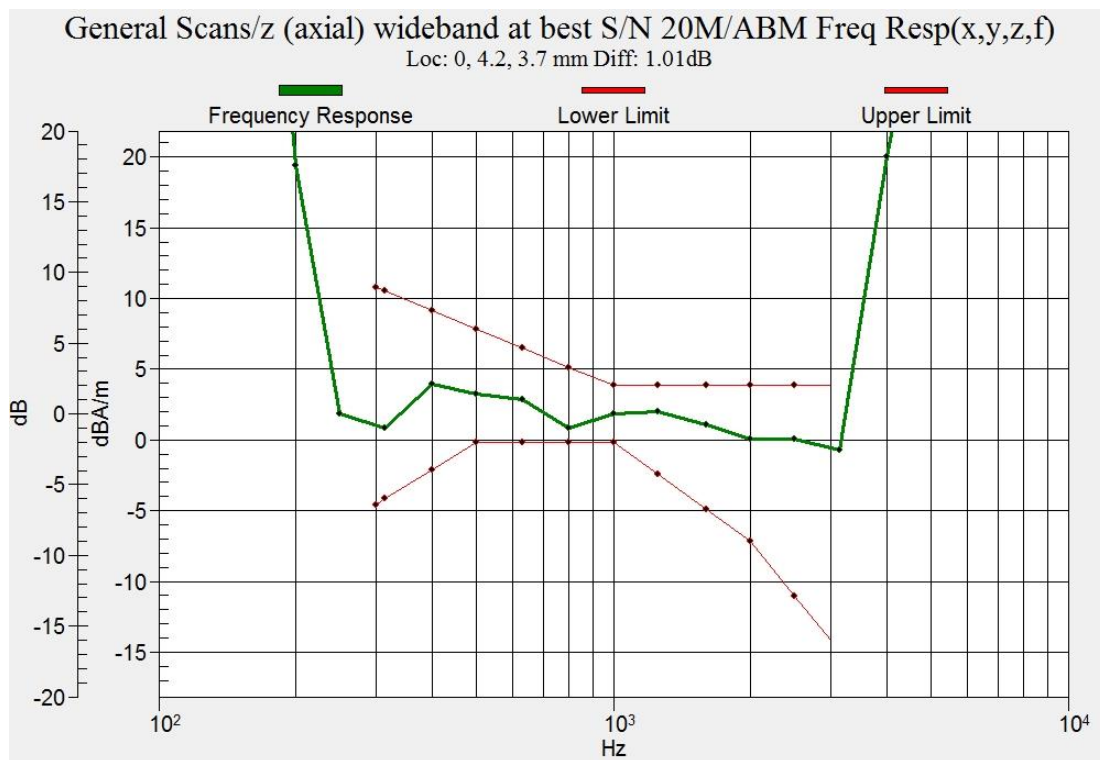
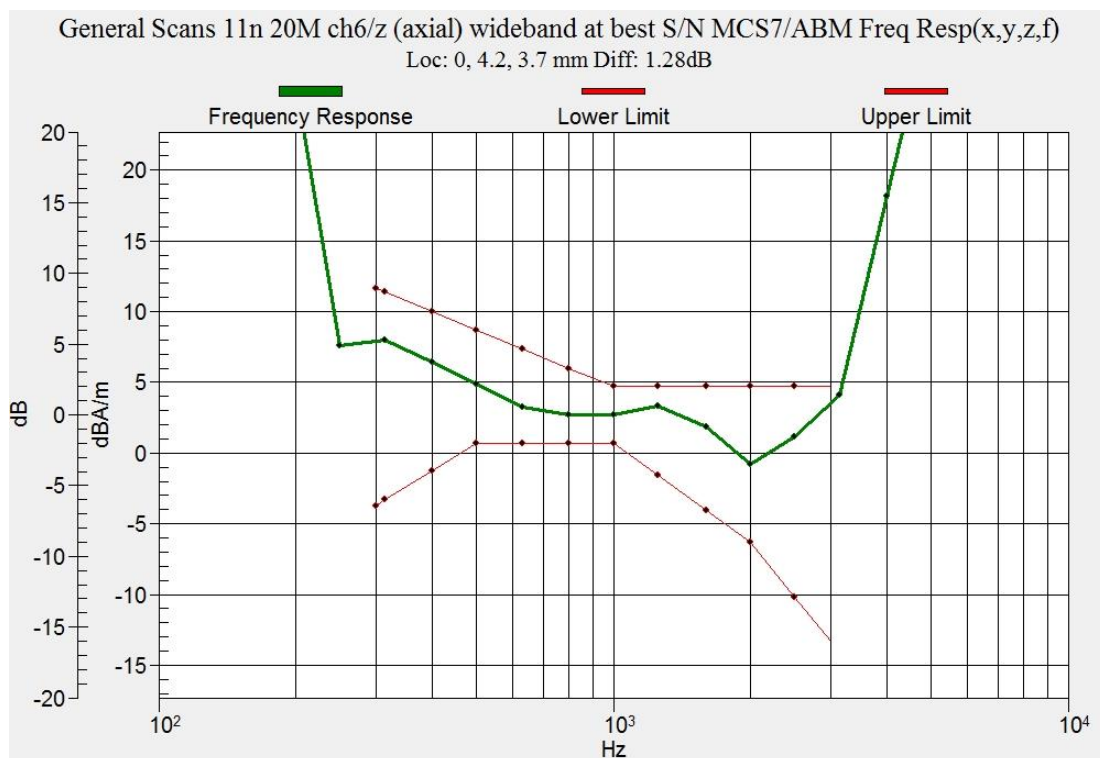


Figure F.5.2 Frequency Response of WCDMA 1900



**Figure F.5.3 Frequency Response of LTE B2**



**Figure F.5.4 Frequency Response of WiFi 2.4G**

## F.6 Frequency response curves of Google duo

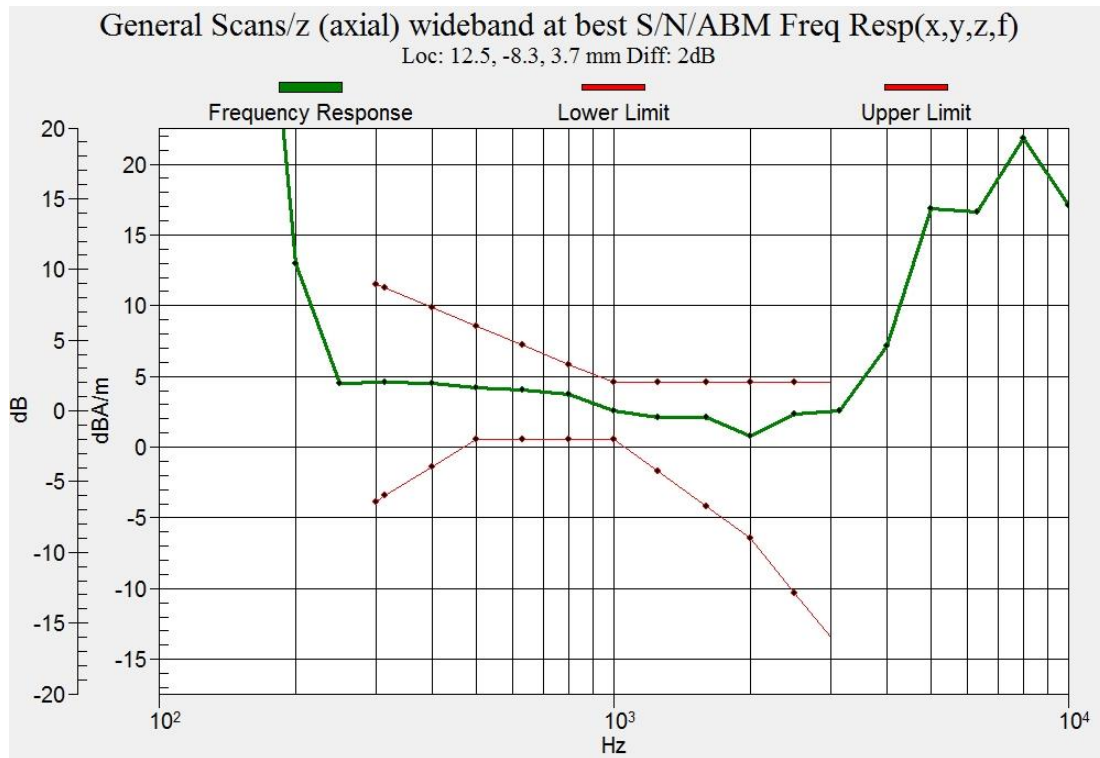


Figure F.6.1 Frequency Response of WCDMA 1700

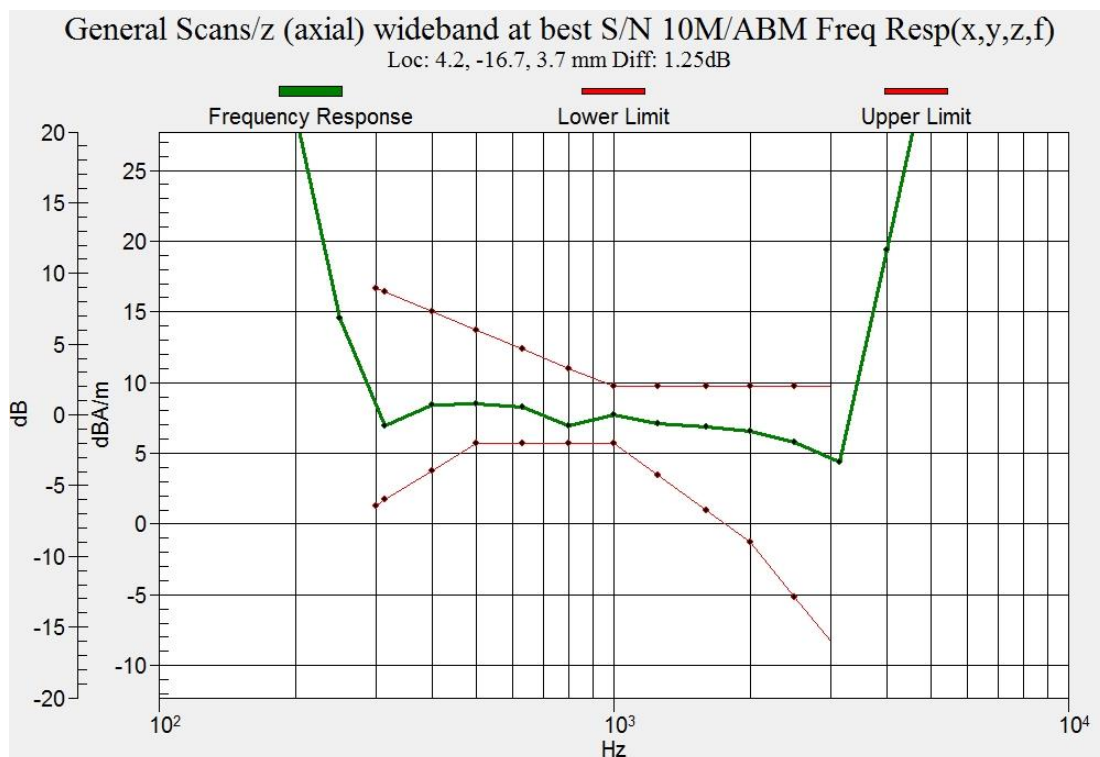


Figure F.6.2 Frequency Response of LTE B4

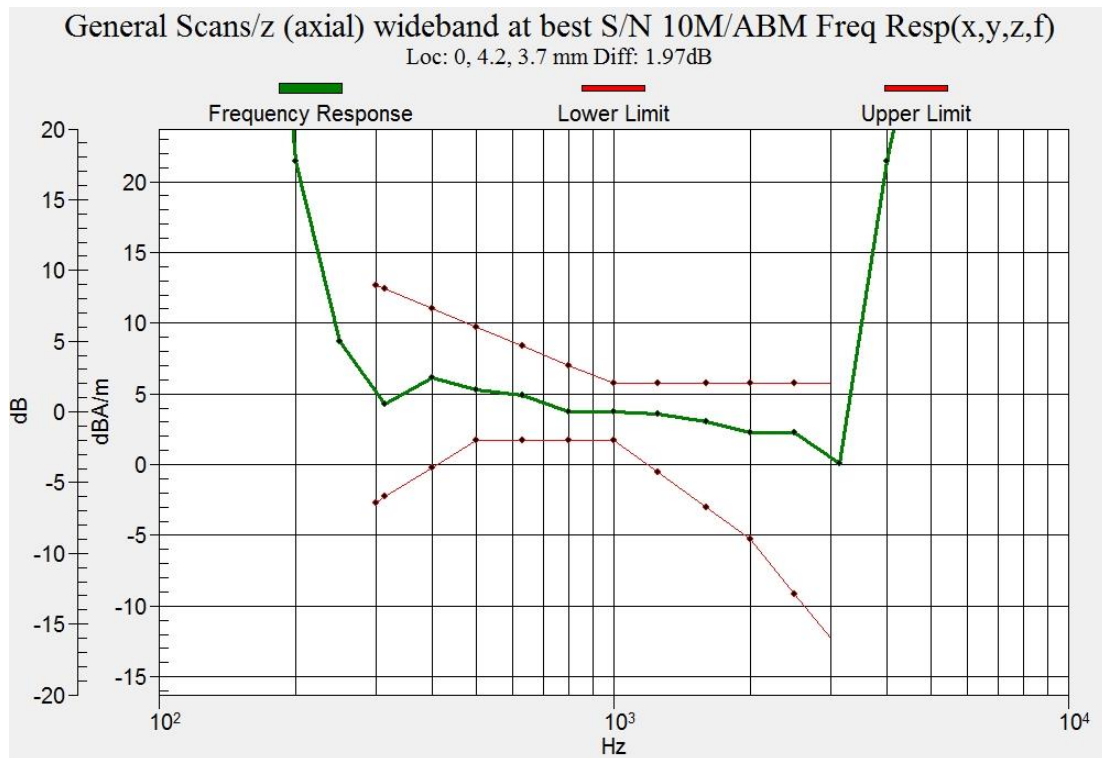


Figure F.6.3 Frequency Response of WiFi 2.4G

**The photos of HAC test are presented in the additional document:**

Appendix to test report no. I19Z62348-SEM01/02

The photos of HAC test