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Report On

Specific Absorption Rate Testing of the
Echostar S55

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SECTION 1

REPORT SUMMARY

Specific Absorption Rate Testing of the
Echostar S55



1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Specific Absorption Rate Testing of the Echostar S55 to the requirements of KDB 447498 D01 v06 General RF Exposure Guidance.

| | |
|-------------------------------|---|
| Objective | To perform Specific Absorption Rate Testing to determine the Equipment Under Test's (EUT's) compliance with the requirements specified of KDB 447498 D01 v06 General RF Exposure Guidance, for the series of tests carried out. |
| Applicant | SmarDTV |
| Manufacturer | Echostar |
| Model | S55 |
| Serial/IMEI Number(s) | Not Serialised |
| Number of Samples Tested | 1 |
| Hardware Version | P6 |
| Software Version | Not Declared |
| Test Specification/Issue/Date | KDB 447498 D01 v06 General RF Exposure Guidance |
| Start of Test | 25 March 2017 |
| Finish of Test | 30 March 2017 |
| Related Document(s) | FCC 47CFR 2.1093: 2015 RSS-102 Issue 5 KDB 865664 – D01 v01r04 KDB 865664 – D02 v01r02 KDB 447498 – D01 v06 KDB 248227 – D01 v02r02 KDB 941225 – D01 v01r02 IEEE 1528-2013 |
| Name of Engineer(s) | Stephen Dodd |



1.2 BRIEF SUMMARY OF RESULTS

The measurements shown in this report were made in accordance with the procedures specified KDB 447498 D01 v06 General RF Exposure Guidance.

The maximum 1g volume averaged stand-alone SAR found during this Assessment:

| | | |
|---|------------------------|----------------------|
| Max 1g SAR (W/kg) Body | 0.72 (Measured) | 0.84 (Scaled) |
| The maximum 1g volume averaged SAR level measured for all the tests performed did not exceed the limits for General Population/Uncontrolled Exposure (W/kg) Partial Body of 1.6 W/kg. | | |

The maximum 1g volume averaged stand-alone Reported SAR found during this Assessment for each supported mode:

| Band | Test Configuration | Max Reported SAR (W/kg) |
|---|--------------------|-------------------------|
| U-NII-2A | Body | 0.60 |
| U-NII-2C | Body | 0.76 |
| U-NII-3 | Body | 0.84 |
| The maximum 1g volume averaged SAR level measured for all the tests performed did not exceed the limits for General Population/Uncontrolled Exposure (W/kg) Partial Body of 1.6 W/kg. | | |



1.3 TEST RESULTS SUMMARY

1.3.1 System Performance / Validation Check Results

Prior to formal testing being performed a System Check was performed in accordance with KDB 865664 and the results were compared against published data in Standard IEEE 1528-2003. The following results were obtained: -

System performance / Validation results

| Date | Dipole | Frequency (MHz) | Max 1g SAR (W/kg)* | Percentage Drift on Reference |
|------------|--------|-----------------|--------------------|-------------------------------|
| 25/03/2017 | D5000 | 5800 | 70.86 | -4.37 |
| 27/03/2017 | D5000 | 5800 | 66.88 | -9.74 |
| 27/03/2017 | D5000 | 5200 | 74.05 | 3.13 |
| 28/03/2017 | D5000 | 5200 | 73.65 | 2.58 |
| 28/03/2017 | D5000 | 5500 | 78.43 | -0.85 |
| 29/03/2017 | D5000 | 5500 | 79.74 | 0.81 |
| 30/03/2017 | D5000 | 5800 | 72.06 | 0.03 |

*Normalised to a forward power of 1W

1.3.2 Results Summary Tables

WLAN U-NII-2A 802.11n 40MHz HT0 Antenna 0: Body Specific Absorbtion Rate (Maximum SAR) 1g Results

| Test Position | Channel Number | Frequency (MHz) | Measured Average Power (dBm) | Tune Up (dBm) | Measured 1g SAR (W/kg) | Scaled 1g SAR (W/kg) | Scan Figure Number |
|-----------------|----------------|-----------------|------------------------------|---------------|------------------------|----------------------|--------------------|
| 5mm Rear Facing | 54 | 5270 | 14.58 | 16.00 | 0.40 | 0.55 | Figure 2 |
| 5mm Top Edge | 54 | 5270 | 14.58 | 16.00 | 0.40 | 0.55 | Figure 3 |
| 5mm Right Edge | 54 | 5270 | 14.58 | 16.00 | 0.06 | 0.08 | Figure 4 |
| 5mm Left Edge | 54 | 5270 | 14.58 | 16.00 | 0.27 | 0.37 | Figure 5 |

Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g).

WLAN U-NII-2A 802.11n 40MHz HT0 Antenna 1: Body Specific Absorbtion Rate (Maximum SAR) 1g Results

| Test Position | Channel Number | Frequency (MHz) | Measured Average Power (dBm) | Tune Up (dBm) | Measured 1g SAR (W/kg) | Scaled 1g SAR (W/kg) | Scan Figure Number |
|------------------|----------------|-----------------|------------------------------|---------------|------------------------|----------------------|--------------------|
| 5mm Front Facing | 54 | 5270 | 14.96 | 16.00 | 0.47 | 0.60 | Figure 6 |
| 5mm Bottom Edge | 54 | 5270 | 14.96 | 16.00 | 0.23 | 0.29 | Figure 7 |
| 5mm Right Edge | 54 | 5270 | 14.96 | 16.00 | 0.08 | 0.10 | Figure 8 |
| 5mm Left Edge | 54 | 5270 | 14.96 | 16.00 | 0.13 | 0.17 | Figure 9 |

Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)



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WLAN U-NII-2C 802.11n 20MHz HT0 Antenna 0: Body Specific Absorbtion Rate (Maximum SAR) 1g Results

| Test Position | Channel Number | Frequency (MHz) | Measured Average Power (dBm) | Tune Up (dBm) | Measured 1g SAR (W/kg) | Scaled 1g SAR (W/kg) | Scan Figure Number |
|--|----------------|-----------------|------------------------------|---------------|------------------------|----------------------|--------------------|
| 5mm Rear Facing | 116 | 5580 | 14.80 | 16.00 | 0.38 | 0.50 | Figure 10 |
| 5mm Top Edge | 116 | 5580 | 14.80 | 16.00 | 0.58 | 0.76 | Figure 11 |
| 5mm Right Edge | 116 | 5580 | 14.80 | 16.00 | 0.07 | 0.09 | Figure 12 |
| 5mm Left Edge | 116 | 5580 | 14.80 | 16.00 | 0.39 | 0.51 | Figure 13 |
| Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) | | | | | | | |

WLAN U-NII-2C 802.11n 20MHz HT0 Antenna 1: Body Specific Absorbtion Rate (Maximum SAR) 1g Results

| Test Position | Channel Number | Frequency (MHz) | Measured Average Power (dBm) | Tune Up (dBm) | Measured 1g SAR (W/kg) | Scaled 1g SAR (W/kg) | Scan Figure Number |
|--|----------------|-----------------|------------------------------|---------------|------------------------|----------------------|--------------------|
| 5mm Front Facing | 116 | 5580 | 15.15 | 16.00 | 0.58 | 0.71 | Figure 14 |
| 5mm Bottom Edge | 116 | 5580 | 15.15 | 16.00 | 0.26 | 0.32 | Figure 15 |
| 5mm Right Edge | 116 | 5580 | 15.15 | 16.00 | 0.08 | 0.10 | Figure 16 |
| 5mm Left Edge | 116 | 5580 | 15.15 | 16.00 | 0.17 | 0.21 | Figure 17 |
| Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) | | | | | | | |

WLAN U-NII-3 802.11n 40MHz HT0 Antenna 0: Body Specific Absorbtion Rate (Maximum SAR) 1g Results

| Test Position | Channel Number | Frequency (MHz) | Measured Average Power (dBm) | Tune Up (dBm) | Measured 1g SAR (W/kg) | Scaled 1g SAR (W/kg) | Scan Figure Number |
|--|----------------|-----------------|------------------------------|---------------|------------------------|----------------------|--------------------|
| 5mm Rear Facing | 151 | 5755 | 14.65 | 16.00 | 0.36 | 0.49 | Figure 18 |
| 5mm Top Edge | 151 | 5755 | 14.65 | 16.00 | 0.42 | 0.57 | Figure 19 |
| 5mm Right Edge | 151 | 5755 | 14.65 | 16.00 | 0.06 | 0.08 | Figure 20 |
| 5mm Left Edge | 151 | 5755 | 14.65 | 16.00 | 0.30 | 0.41 | Figure 21 |
| Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) | | | | | | | |

WLAN U-NII-3 802.11n 40MHz HT0 Antenna 1: Body Specific Absorbtion Rate (Maximum SAR) 1g Results

| Test Position | Channel Number | Frequency (MHz) | Measured Average Power (dBm) | Tune Up (dBm) | Measured 1g SAR (W/kg) | Scaled 1g SAR (W/kg) | Scan Figure Number |
|--|----------------|-----------------|------------------------------|---------------|------------------------|----------------------|--------------------|
| 5mm Front Facing | 151 | 5755 | 15.35 | 16.00 | 0.72 | 0.84 | Figure 22 |
| 5mm Bottom Edge | 151 | 5755 | 15.35 | 16.00 | 0.27 | 0.31 | Figure 23 |
| 5mm Right Edge | 151 | 5755 | 15.35 | 16.00 | 0.09 | 0.10 | Figure 24 |
| 5mm Left Edge | 151 | 5755 | 15.35 | 16.00 | 0.24 | 0.28 | Figure 25 |
| 5mm Front Face | 159 | 5795 | 14.98 | 16.00 | 0.59 | 0.75 | Figure 26 |
| Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) | | | | | | | |



1.3.3 Simultaneous Transmission

| Position | 802.11n 40MHz HT0 1g SAR (W/kg) | 802.11n 40MHz HT0 1g SAR (W/kg) | Bluetooth Estimated 1 g SAR W/kg) | Σ 1g SAR (W/kg) |
|--|---|---|--|------------------------|
| Body | Antenna 0 CH 54 (Scaled SAR values) | Antenna 1 CH 54 (Scaled SAR values) | | |
| Front | N/A | 0.60 | 0.40 | 1.00 |
| Rear | 0.55 | N/A | N/A | 0.55 |
| Top | 0.55 | N/A | 0.40 | 0.95 |
| Bottom | N/A | 0.29 | N/A | 0.29 |
| Right | 0.08 | N/A | 0.40 | 0.08 |
| Right | N/A | 0.10 | 0.40 | 0.50 |
| Left | 0.37 | N/A | 0.40 | 0.77 |
| Left | N/A | 0.17 | 0.40 | 0.57 |
| The highest reported SAR for the 802.11 transmission modes in the frequency band was used for simultaneous transmission SAR test exclusion. Simultaneous Transmission KDB 447498 D01 | | | | |

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

| Position | 802.11n 20MHz HT0 1g SAR (W/kg) | 802.11n 20MHz HT0 1g SAR (W/kg) | Bluetooth Estimated 1 g SAR W/kg) | Σ 1g SAR (W/kg) |
|--|--|--|--|------------------------|
| Body | Antenna 0 CH 116 (Scaled SAR values) | Antenna 1 CH 116 (Scaled SAR values) | | |
| Front | N/A | 0.71 | 0.40 | 1.11 |
| Rear | 0.50 | N/A | N/A | 0.50 |
| Top | 0.76 | N/A | 0.40 | 1.16 |
| Bottom | N/A | 0.32 | N/A | 0.32 |
| Right | 0.09 | N/A | 0.40 | 0.49 |
| Right | N/A | 0.10 | 0.40 | 0.50 |
| Left | 0.51 | N/A | 0.40 | 0.91 |
| Left | N/A | 0.21 | 0.40 | 0.61 |
| The highest reported SAR for the 802.11 transmission modes in the frequency band was used for simultaneous transmission SAR test exclusion. Simultaneous Transmission KDB 447498 D01 | | | | |

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.



| Position | 802.11n 20MHz HT0 1g SAR (W/kg) Antenna 0 CH 116 (Scaled SAR values) | 802.11n 20MHz HT0 1g SAR (W/kg) Antenna 1 CH 116 (Scaled SAR values) | Bluetooth Estimated 1 g SAR W/kg) | Σ 1g SAR (W/kg) |
|--|---|---|--|------------------------|
| Front | N/A | 0.84 | 0.40 | 1.24 |
| Rear | 0.49 | N/A | N/A | 0.49 |
| Top | 0.57 | N/A | 0.40 | 0.97 |
| Bottom | N/A | 0.31 | N/A | 0.31 |
| Right | 0.08 | N/A | 0.40 | 0.48 |
| Right | N/A | 0.10 | 0.40 | 0.50 |
| Left | 0.41 | N/A | 0.40 | 0.81 |
| Left | N/A | 0.28 | 0.40 | 0.68 |
| The highest reported SAR for the 802.11 transmission modes in the frequency band was used for simultaneous transmission SAR test exclusion. Simultaneous Transmission KDB 447498 D01 | | | | |

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

1.3.4 Standalone SAR Estimation

When the standalone SAR test exclusion of section 4.3.1 is applied to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to the following to determine simultaneous transmission SAR test exclusion. The estimated SAR is only used to determine simultaneous transmission SAR test exclusion; When SAR is estimated, it must be applied to determine the sum of 1-g SAR test exclusion. When SAR to peak location separation ratio test exclusion is applied, the highest reported SAR for simultaneous transmission can be an estimated standalone SAR if the estimated SAR is the highest among the simultaneously transmitting antennas (see KDB 690783).

(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)]·[$\sqrt{f(\text{GHz})/7.5}$] W/kg for test separation distances \leq 50 mm;

where $x = 7.5$ for 1-g SAR, and $x = 18.75$ for 10-g SAR

when the minimum test separation distance is <5 mm, a distance of 5mm is applied.

Bluetooth SAR Estimation

| Test Configuration | Frequency (MHz) | Maximum Power (mW) | Distance (mm) | Estimated SAR (W/kg) |
|--------------------|-----------------|--------------------|---------------|----------------------|
| Body | 2402 | 9.5 | 5 | 0.40 |
| Body | 2442 | 9.5 | 5 | 0.40 |
| Body | 2480 | 9.5 | 5 | 0.40 |



1.3.5 Standalone SAR Test Exclusion Considerations (KDB 447498 D01)

The 1g SAR Test exclusion thresholds for 100 MHz to 6 GHz *test separation distances* \leq 50 mm are determined by:

$[(\text{max power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] / [f_{(\text{GHz})}] \leq 3.0$, where

- $f_{(\text{GHz})}$ is the RF channel transmit frequency in GHz.
- Power and distance are rounded to the nearest mW and mm before calculation.
- The result is rounded to one decimal place for comparison.
- When the maximum test separation distance is < 5 mm, a distance of 5 mm is applied.

| Band | Frequency (MHz) | Power (dBm) | Power (mW) | Test Position | Distance (mm) | Threshold | Test Exclusion |
|-----------|-----------------|-------------|------------|---------------|---------------|-----------|----------------|
| U-NII- 2A | 5270 | 16.00 | 39.8 | Body | 5 | 18.3 | No |
| U-NII-2a | 5520 | 16.00 | 39.8 | Body | 5 | 18.7 | No |
| U-NII-3 | 5795 | 16.00 | 39.8 | Body | 5 | 19.2 | No |

1.3.6 Technical Description

The equipment under test (EUT) was an Echostar S55. A full technical description can be found in the manufacturer's documentation.

1.3.7 Test Configuration and Modes of Operation

The testing was performed with an integral battery. There were no external connections.

WLAN testing was achieved using the devices internal software, customer supplied software and settings supplied by the customer. For each scan the device was configured into a continuous transmission test mode.

The worst case data rate for WLAN testing was obtained from data provided by TUV. The worst case was deemed as the data rate which produced the highest level of conducted average power. The worst case data rates used for testing were U-NII-2A 802.11n 40 MHz HT0, U-NII-2C 802.11n 20 MHz HT0, U-NII-3 802.11n 40 MHz HT0.

As the overall diagonal dimension of the DUT is \leq 20 cm KDB 941225 D07 was referred to. All faces of the DUT within 25mm of the antenna were tested.

For body SAR assessment the DUT was positioned against an Elliptical phantom with a 5mm separation distance

The Elliptical Phantom dimensions are 600 mm major axis and 400mm minor axis with a shell thickness of 2.00mm. The phantom was filled to a minimum depth of 150mm with the appropriate simulant liquid. The dielectric properties were in accordance with the requirements specified in KDB 865665.

Included in this report are descriptions of the test method; the equipment used and an analysis of the test uncertainties applicable and diagrams indicating the locations of maximum SAR for each test position.



1.4 FCC POWER MEASUREMENTS

1.4.1 Method

Conducted power measurements were made using a power meter.

1.4.2 Conducted Power Measurements

WLAN 5000 MHz

| Mode | Frequency (MHz) | Duty Cycle (%) | Burst Average Power (dBm) Antenna 0 | Burst Average Power (dBm) Antenna 1 | Tune up limit |
|--------------------------------|-----------------|----------------|-------------------------------------|-------------------------------------|---------------|
| 802.11a - 20 MHz - 6 Mbps OFDM | 5180 | 100 | 10.41 | 10.45 | 11.5 |
| 802.11a - 20 MHz - 6 Mbps OFDM | 5260 | 100 | 14.12 | 14.32 | 16 |
| 802.11a - 20 MHz - 6 Mbps OFDM | 5320 | 100 | 13.1 | 13.72 | 15 |
| 802.11a - 20 MHz - 6 Mbps OFDM | 5500 | 100 | 13.15 | 13.45 | 15 |
| 802.11a - 20 MHz - 6 Mbps OFDM | 5580 | 100 | 14.2 | 14.3 | 16 |
| 802.11a - 20 MHz - 6 Mbps OFDM | 5720 | 100 | 14.5 | 14.89 | 16 |
| 802.11a - 20 MHz - 6 Mbps OFDM | 5745 | 100 | 14.3 | 14.8 | 16 |
| 802.11a - 20 MHz - 6 Mbps OFDM | 5785 | 100 | 14.05 | 14.81 | 16 |
| 802.11a - 20 MHz - 6 Mbps OFDM | 5825 | 100 | 14.25 | 14.78 | 16 |
| 802.11n - 20 MHz - HT0 | 5180 | 100 | 9.89 | 10.1 | 11.5 |
| 802.11n - 20 MHz - HT0 | 5260 | 100 | 14.1 | 14.15 | 16 |
| 802.11n - 20 MHz - HT0 | 5320 | 100 | 14.75 | 15.1 | 16 |
| 802.11n - 20 MHz - HT0 | 5500 | 100 | 13.16 | 13.2 | 15 |
| 802.11n - 20 MHz - HT0 | 5580 | 100 | 14.8 | 15.15 | 16 |
| 802.11n - 20 MHz - HT0 | 5720 | 100 | 14.62 | 14.85 | 16 |
| 802.11n - 20 MHz - HT0 | 5745 | 100 | 14.06 | 14.7 | 16 |
| 802.11n - 20 MHz - HT0 | 5785 | 100 | 14.25 | 14.8 | 16 |
| 802.11n - 20 MHz - HT0 | 5825 | 100 | 14.22 | 14.62 | 16 |
| 802.11n - 40 MHz - HT0 | 5190 | 100 | 10.75 | 11.36 | 11.5 |
| 802.11n - 40 MHz - HT0 | 5270 | 100 | 14.58 | 14.96 | 16 |
| 802.11n - 40 MHz - HT0 | 5310 | 100 | 12.8 | 13.5 | 14 |
| 802.11n - 40 MHz - HT0 | 5510 | 100 | 11.44 | 11.8 | 12.5 |
| 802.11n - 40 MHz - HT0 | 5550 | 100 | 14.51 | 15.07 | 16 |
| 802.11n - 40 MHz - HT0 | 5710 | 100 | 14.1 | 14.2 | 16 |
| 802.11n - 40 MHz - HT0 | 5755 | 100 | 14.65 | 15.35 | 16 |
| 802.11n - 40 MHz - HT0 | 5795 | 100 | 14.51 | 14.98 | 16 |
| 802.11ac - 80 MHz - VHT0 | 5210 | 100 | 10.6 | 11.3 | 12 |
| 802.11ac - 80 MHz - VHT0 | 5290 | 100 | 11.85 | 12.5 | 13.5 |
| 802.11ac - 80 MHz - VHT0 | 5530 | 100 | 10.63 | 11.12 | 12.5 |
| 802.11ac - 80 MHz - VHT0 | 5610 | 100 | 14.29 | 14.48 | 15 |



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| Mode | Frequency (MHz) | Duty Cycle (%) | Burst Average Power (dBm) Antenna 0 | Burst Average Power (dBm) Antenna 1 | Tune up limit |
|--------------------------|-----------------|----------------|--|--|---------------|
| 802.11ac - 80 MHz – VHT0 | 5690 | 100 | 14.41 | 14.6 | 15 |
| 802.11ac - 80 MHz – VHT0 | 5775 | 100 | 13.7 | 13.76 | 15 |

The variation in power is a characteristic of the IC and its calibration process. Also, there was a reduction of the power settings on some of the channels near the band edge in order to pass band edge limits.



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SECTION 2

TEST DETAILS

Specific Absorption Rate Testing of the
Echostar S55



2.1 DASY5 MEASUREMENT SYSTEM

2.1.1 System Description

The DASY5 system for performing compliance tests consists of the following items:

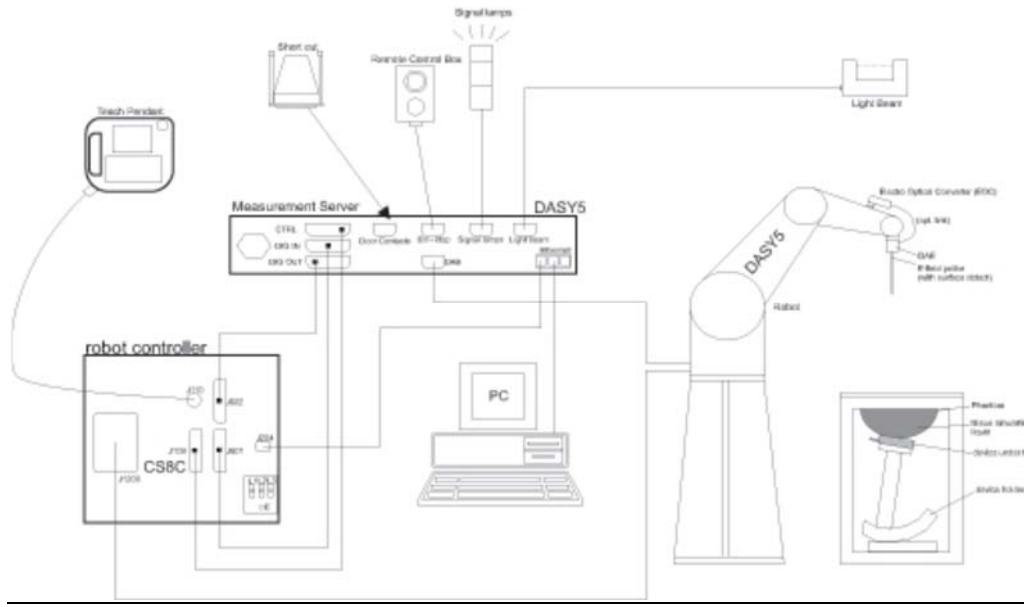


Figure 1 System Description Diagram

A standard high precision 6-axis robot (Stäubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).

An isotropic field probe optimized and calibrated for the targeted measurement.

A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.

The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.

The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.

The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.

A computer running Win7 professional operating system and the DASY5 software.

Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.

The phantom, the device holder and other accessories according to the targeted measurement.



2.1.2 Probe Specification

The probes used by the DASY system are isotropic E-field probes, constructed with a symmetric design and a triangular core. The probes have built-in shielding against static charges and are contained within a PEEK enclosure material. These probes are specially designed and calibrated for use in liquids with high permittivities. The frequency range of the probes are from 6 MHz to 6 GHz.

2.1.3 Data Acquisition Electronics

The data acquisition electronics (DAE4 or DAE3) consist of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder with a control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information, as well as an optical uplink for commands and the clock.

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection. The input impedance of both the DAE4 as well as of the DAE3 box is 200MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

2.1.4 SAR Evaluation Description

The DASY5 software includes all numerical procedures necessary to evaluate the spatial peak SAR values.

Based on the IEEE 1528 standard, a new algorithm has been implemented. The spatial-peak SAR can be computed over any required mass.

The base for the evaluation is a "cube" measurement in a volume of 30mm³ (7x7x7 points). The measured volume must include the 1 g and 10 g cubes with the highest averaged SAR values. For that purpose, the centre of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan. If the 10g cube or both cubes are not entirely inside the measured volumes, the system issues a warning regarding the evaluated spatial peak values within the Post processing engine (SEMCAD X). This means that if the measured volume is shifted, higher values might be possible. To get the correct values you can use a finer measurement grid for the area scan. In complicated field distributions, a large grid spacing for the area scan might miss some details and give an incorrectly interpolated peak location.

The entire evaluation of the spatial peak values is performed within the Post-processing engine (SEMCAD X). The system always gives the maximum values for the 1 g and 10 g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

1. extraction of the measured data (grid and values) from the Zoom Scan
2. calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
3. generation of a high-resolution mesh within the measured volume
4. interpolation of all measured values from the measurement grid to the high-resolution grid
5. extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
6. calculation of the averaged SAR within masses of 1 g and 10 g



2.1.5 Interpolation, Extrapolation and Detection of Maxima

The probe is calibrated at the centre of the dipole sensors which is located 1 to 2.7mm away from the probe tip. During measurements, the probe stops shortly above the phantom surface, depending on the probe and the surface detecting system. Both distances are included as parameters in the probe configuration file. The software always knows exactly how far away the measured point is from the surface. As the probe cannot directly measure at the surface, the values between the deepest measured point and the surface must be extrapolated.

In DASY5, the choice of the coordinate system defining the location of the measurement points has no influence on the uncertainty of the interpolation, Maxima Search and extrapolation routines. The interpolation, extrapolation and maximum search routines are all based on the modified Quadratic Shepard's method [1]. Thereby, the interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation. The DASY5 routines construct a once-continuously differentiable function that interpolates the measurement values as follows:

For each measurement point a trivariate (3-D) / bivariate (2-D) quadratic is computed. It interpolates the measurement values at the data point and forms a least-square fit to neighbouring measurement values. The spatial location of the quadratic with respect to the measurement values is attenuated by an inverse distance weighting. This is performed since the calculated quadratic will fit measurement values at nearby points more accurate than at points located further away.

After the quadratics are calculated for all measurement points, the interpolating function is calculated as a weighted average of the quadratics.

There are two control parameters that govern the behaviour of the interpolation method. One specifies the number of measurement points to be used in computing the least-square fits for the local quadratics. These measurement points are the ones nearest the input point for which the quadratic is being computed. The second parameter specifies the number of measurement points that will be used in calculating the weights for the quadratics to produce the final function. The input data points used there are the ones nearest the point at which the interpolation is desired. Appropriate defaults are chosen for each of the control parameters

The trivariate quadratics that have been previously computed for the 3-D interpolation and whose input data are at the closest distance from the phantom surface, are used in order to extrapolate the fields to the surface of the phantom.

In order to determine all the field maxima in 2-D (Area Scan) and 3-D (Zoom Scan), the measurement grid is refined by a default factor of 10 and the interpolation function is used to evaluate all field values between corresponding measurement points. Subsequently, a linear search is applied to find all the candidate maxima. In a last step, non physical maxima are removed and only those maxima which are within 2 dB of the global maximum value are retained.

In the Area Scan, the gradient of the interpolation function is evaluated to find all the extrema of the SAR distribution. The uncertainty on the locations of the extrema is less than 1/20 of the grid size. Only local maxima within 2 dB of the global maximum are searched and passed for the Zoom Scan measurement.

In the Zoom Scan, the interpolation function is used to extrapolate the Peak SAR from the lowest measurement points to the inner phantom surface (the extrapolation distance). The



uncertainty increases with the extrapolation distance. To keep the uncertainty within 1% for the 1 g and 10 g cubes, the extrapolation distance should not be larger than 5mm.

2.1.6 Averaging and Determination of Spacial Peak SAR

The interpolated data is used to average the SAR over the 1g and 10g cubes by spatially discretising the entire measured volume. The resolution of this spatial grid used to calculate the averaged SAR is 1mm or about 42875 interpolated points. The resulting volumes are defined as cubical volumes containing the appropriate tissue parameters that are centred at the location. The location is defined as the centre of the incremental volume (voxel).

The spatial-peak SAR must be evaluated in cubical volumes containing a mass that is within 5% of the required mass. The cubical volume centred at each location, as defined above, should be expanded in all directions until the desired value for the mass is reached, with no surface boundaries of the averaging volume extending beyond the outermost surface of the considered region. In addition, the cubical volume should not consist of more than 10% of air. If these conditions are not satisfied then the centre of the averaging volume is moved to the next location. Otherwise, the exact size of the final sampling cube is found using an inverse polynomial approximation algorithm, leading to results with improved accuracy. If one boundary of the averaging volume reaches the boundary of the measured volume during its expansion, it will not be evaluated at all. Reference is kept of all locations used and those not used for averaging the SAR. All average SAR values are finally assigned to the centred location in each valid averaging volume.

All locations included in an averaging volume are marked to indicate that they have been used at least once. If a location has been marked as used, but has never been assigned to the centre of a cube, the highest averaged SAR value of all other cubical volumes which have used this location for averaging is assigned to this location. Only those locations that are not part of any valid averaging volume should be marked as unused. For the case of an unused location, a new averaging volume must be constructed which will have the unused location centred at one surface of the cube. The remaining five surfaces are expanded evenly in all directions until the required mass is enclosed, regardless of the amount of included air. Of the six possible cubes with one surface centred on the unused location, the smallest cube is used, which still contains the required mass.

If the final cube containing the highest averaged SAR touches the surface of the measured volume, an appropriate warning is issued within the Post-processing engine.



2.2 WLAN U-NII-2A 802.11n 40 MHz HT0 BODY SAR TEST RESULTS

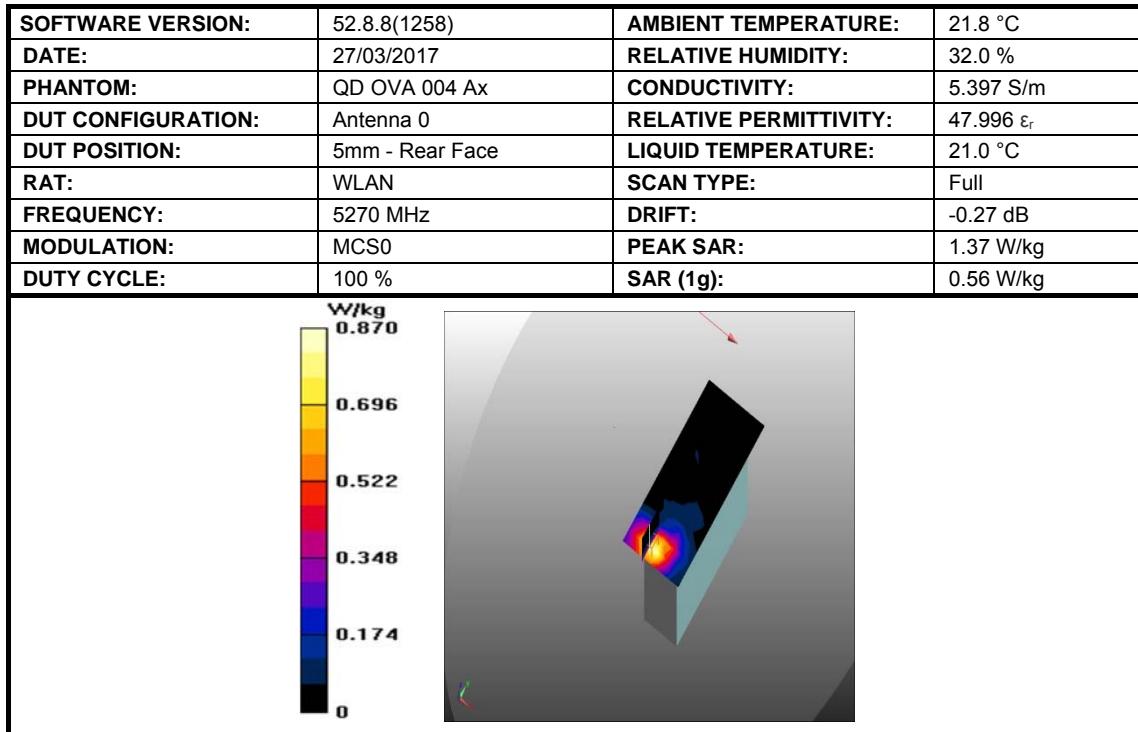


Figure 2: SAR Body Testing Results for the Echostar S55 at 5270 MHz.

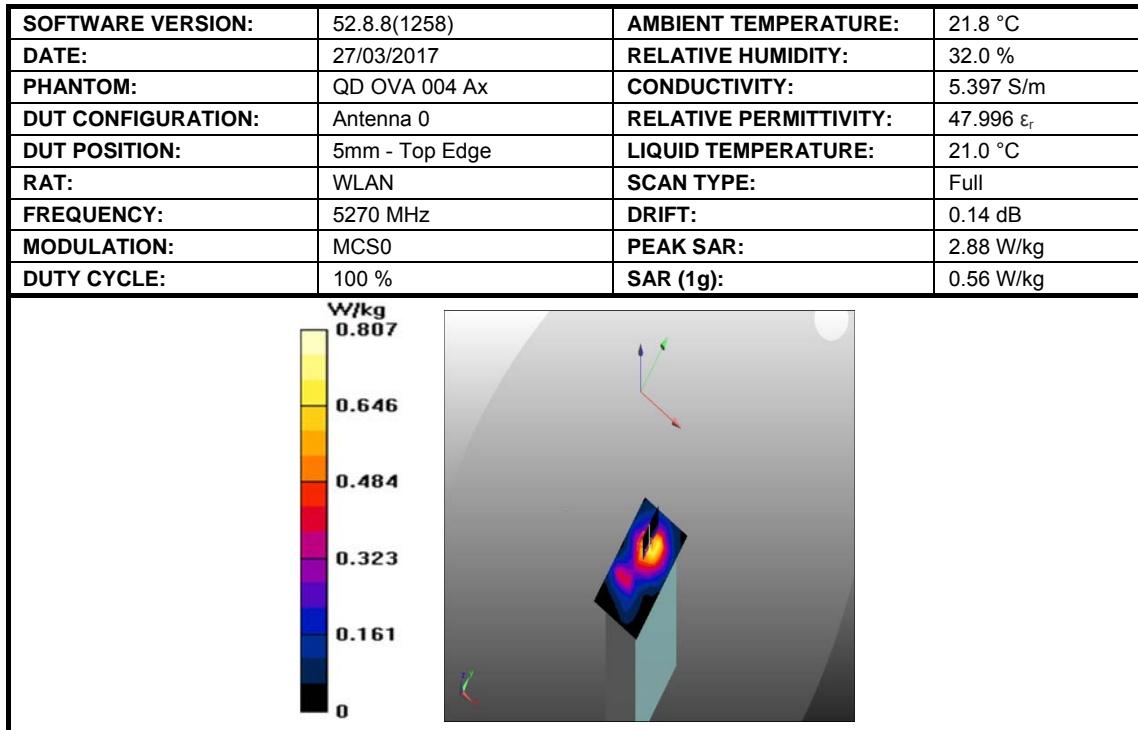


Figure 3: SAR Body Testing Results for the Echostar S55 at 5270 MHz.

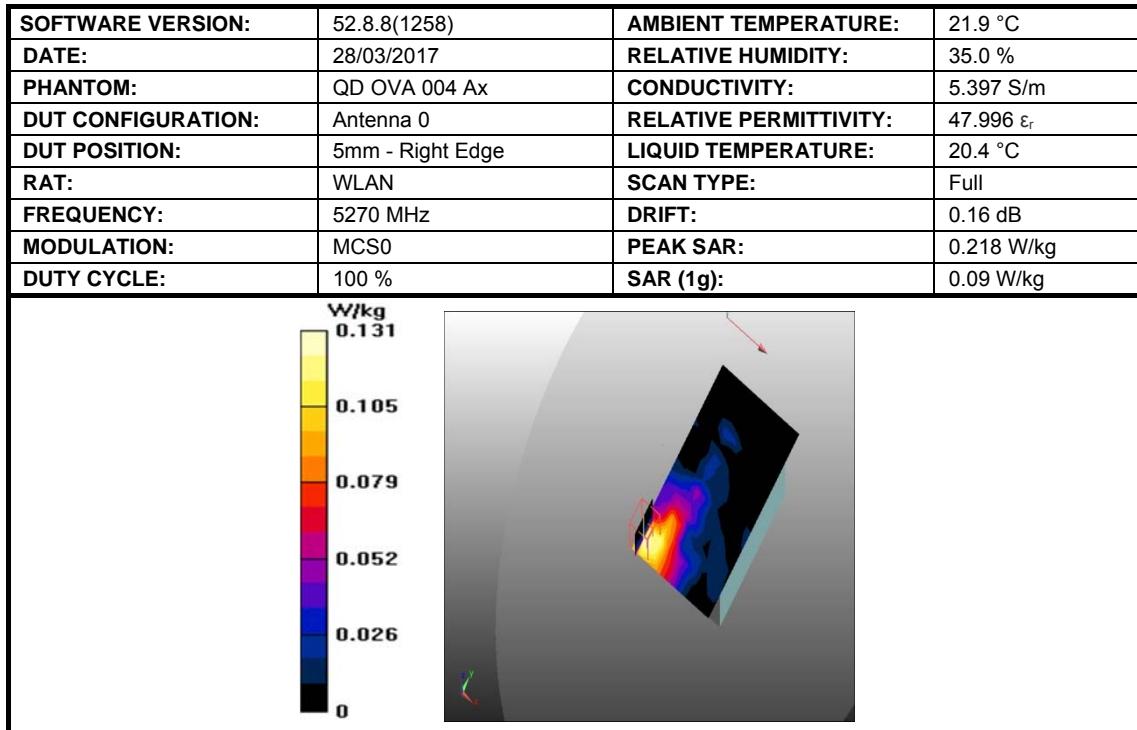


Figure 4: SAR Body Testing Results for the Echostar S55 at 5270 MHz.

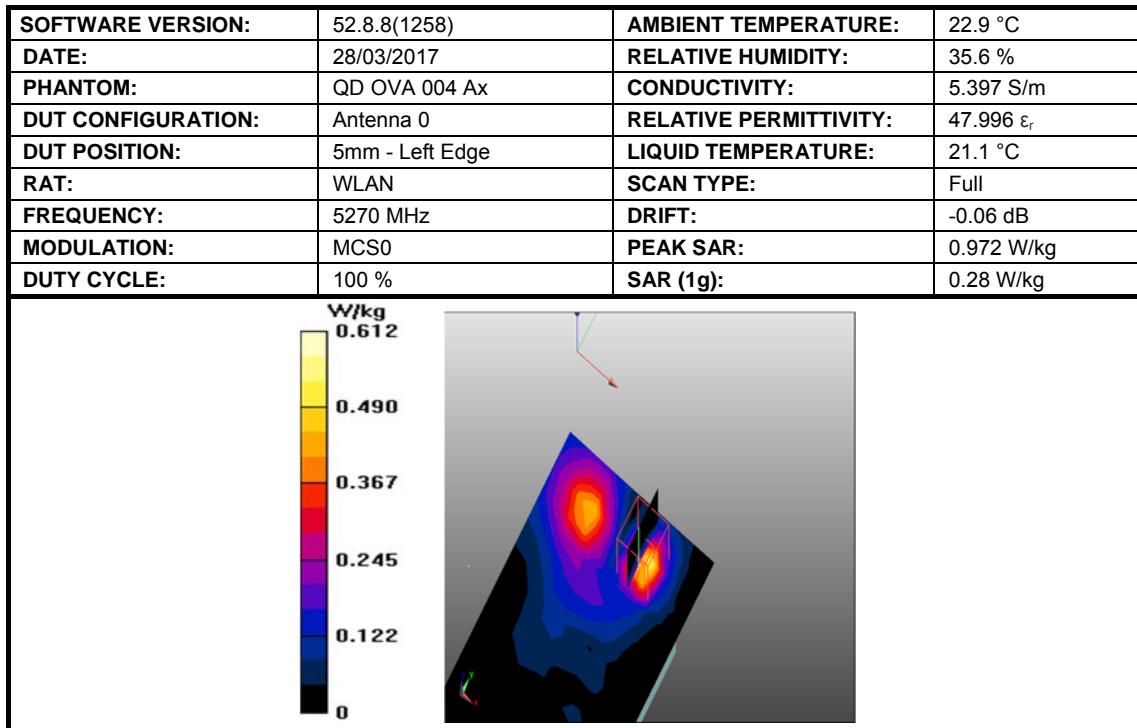


Figure 5: SAR Body Testing Results for the Echostar S55 at 5270 MHz.

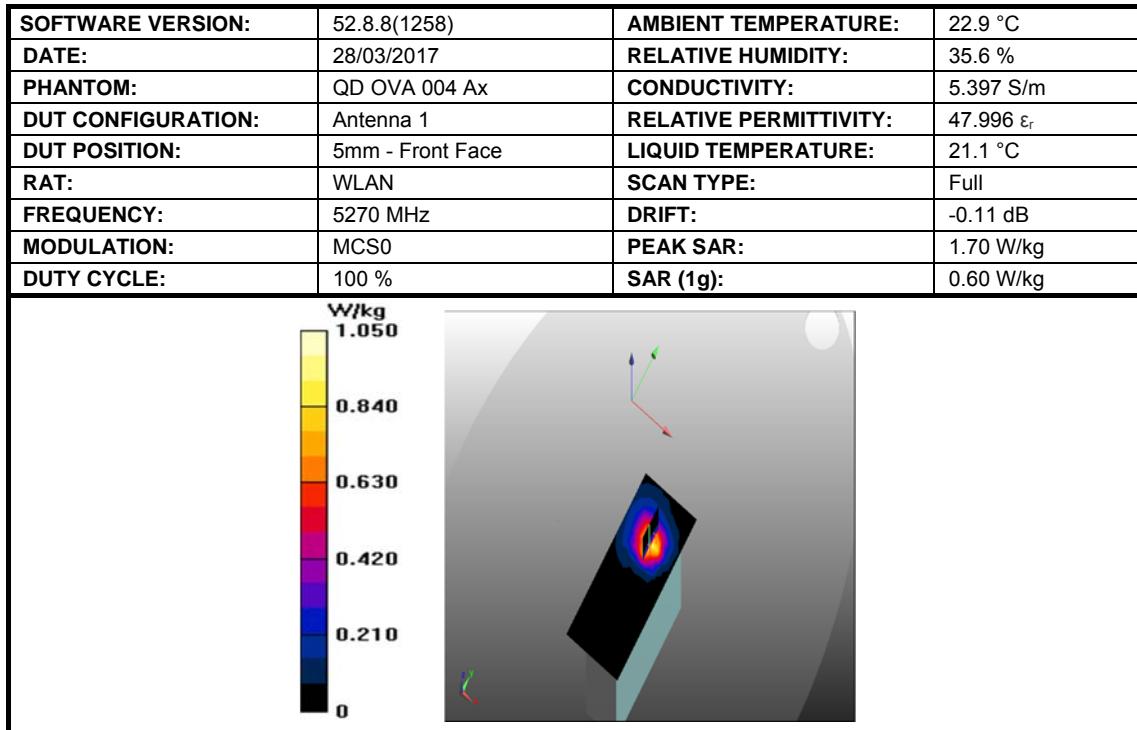


Figure 6: SAR Body Testing Results for the Echostar S55 at 5270 MHz.

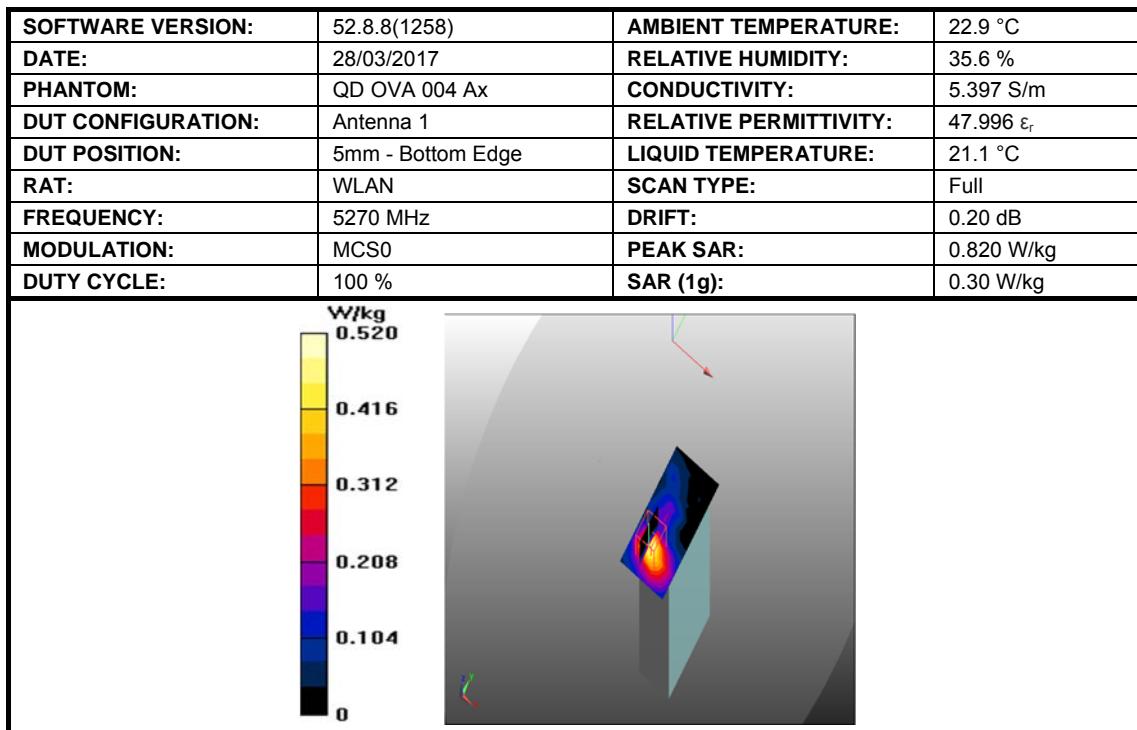


Figure 7: SAR Body Testing Results for the Echostar S55 at 5270 MHz

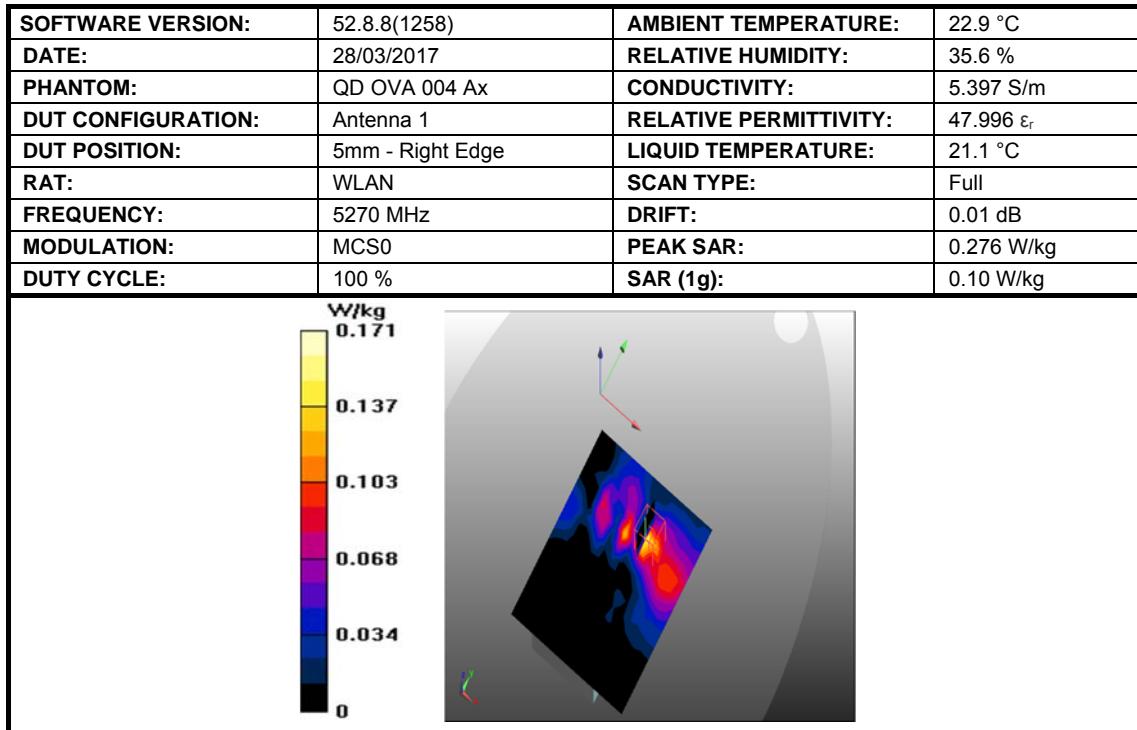


Figure 8: SAR Body Testing Results for the Echostar S55 at 5270 MHz.

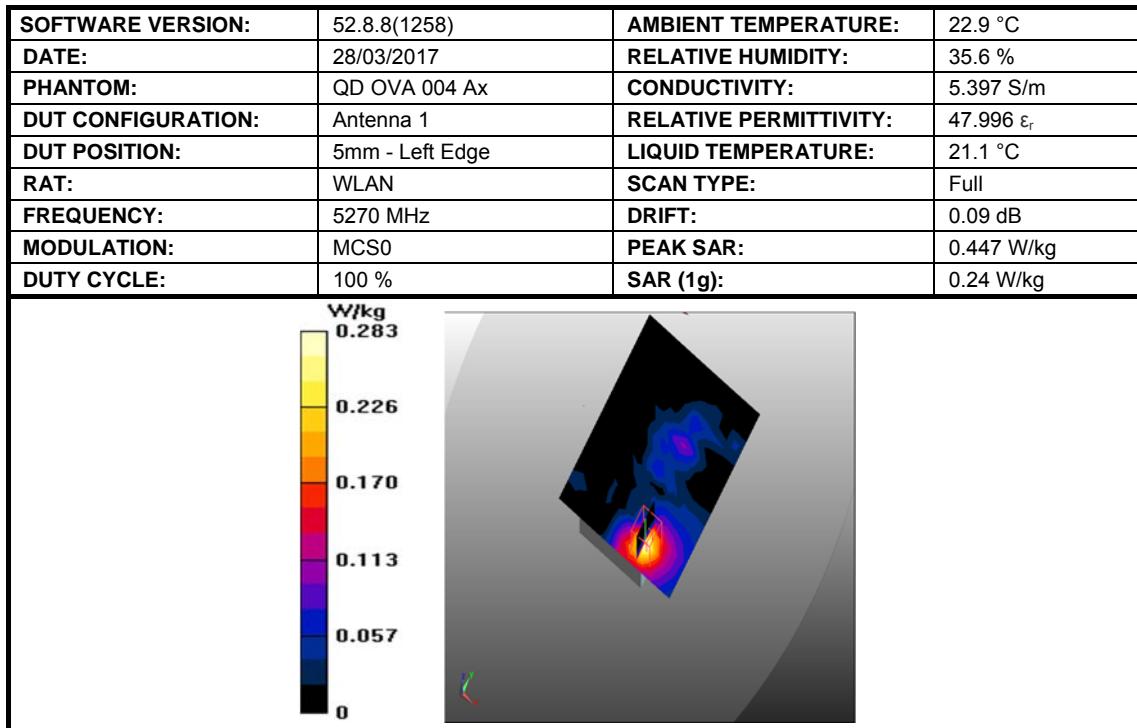


Figure 9: SAR Body Testing Results for the Echostar S55 at 5270 MHz.



2.3 WLAN U-NII-2C 802.11n 20 MHz HT0 BODY SAR TEST RESULTS

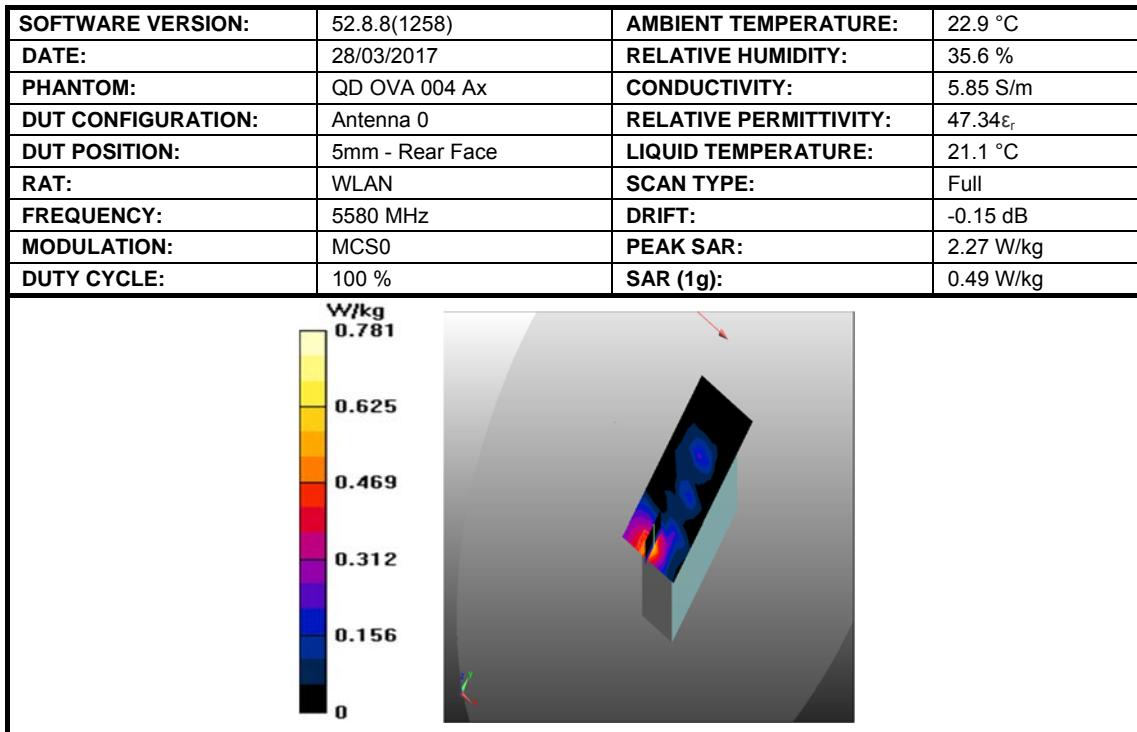


Figure 10: SAR Body Testing Results for the Echostar S55 at 5580 MHz.

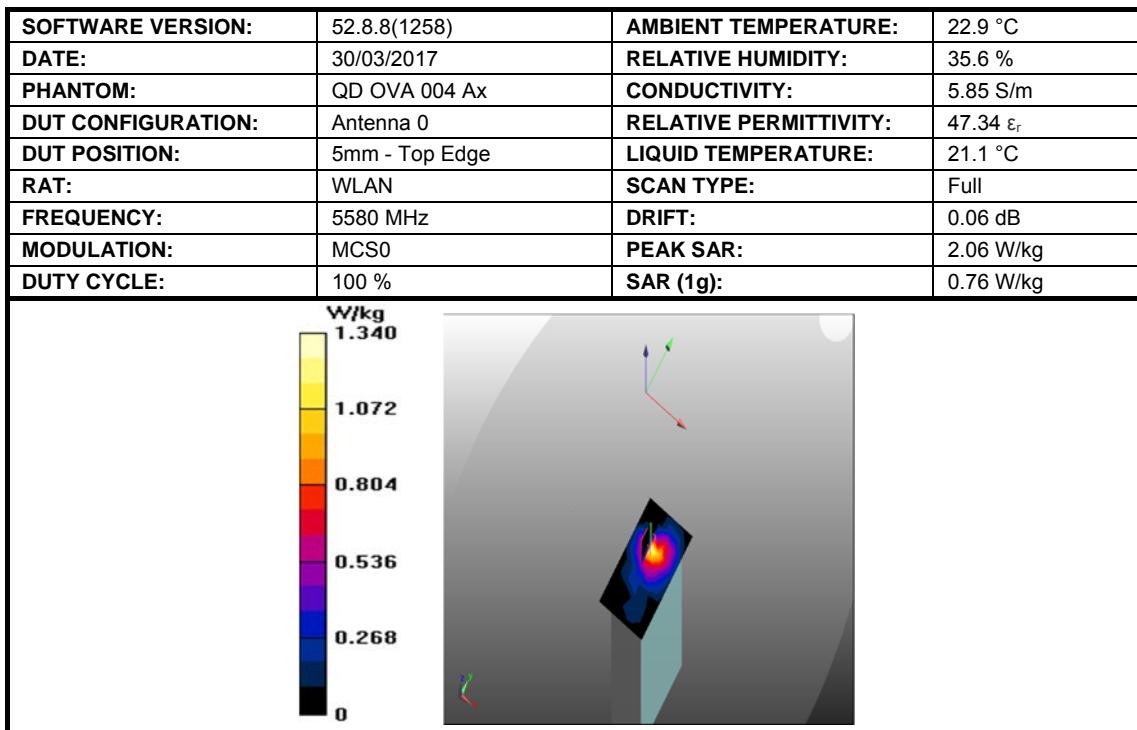


Figure 11: SAR Body Testing Results for the Echostar S55 at 5580 MHz.

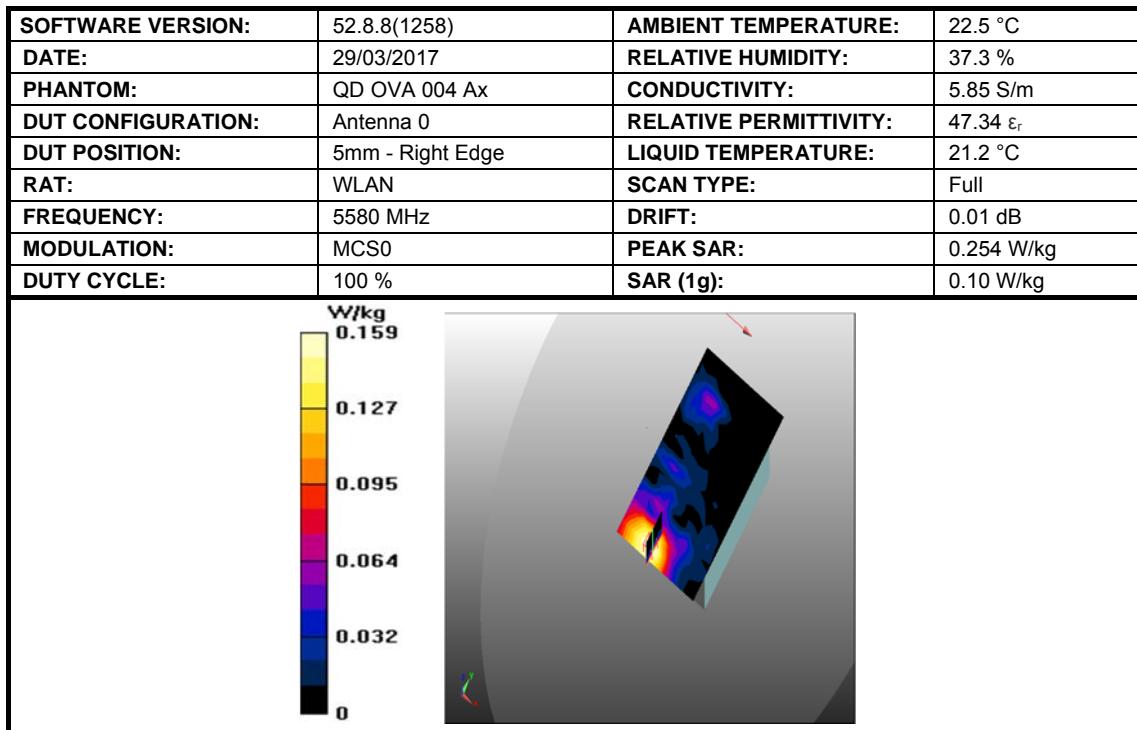


Figure 12: SAR Body Testing Results for the Echostar S55 at 5580 MHz.

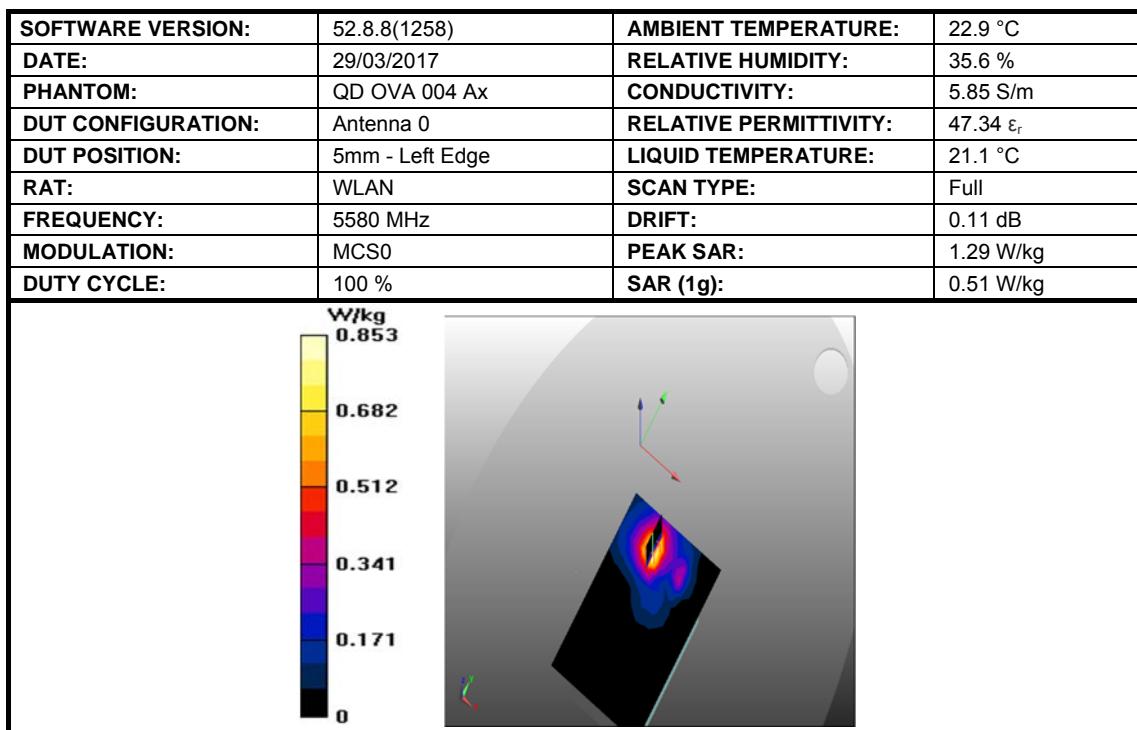


Figure 13: SAR Body Testing Results for the Echostar S55 at 5580 MHz.

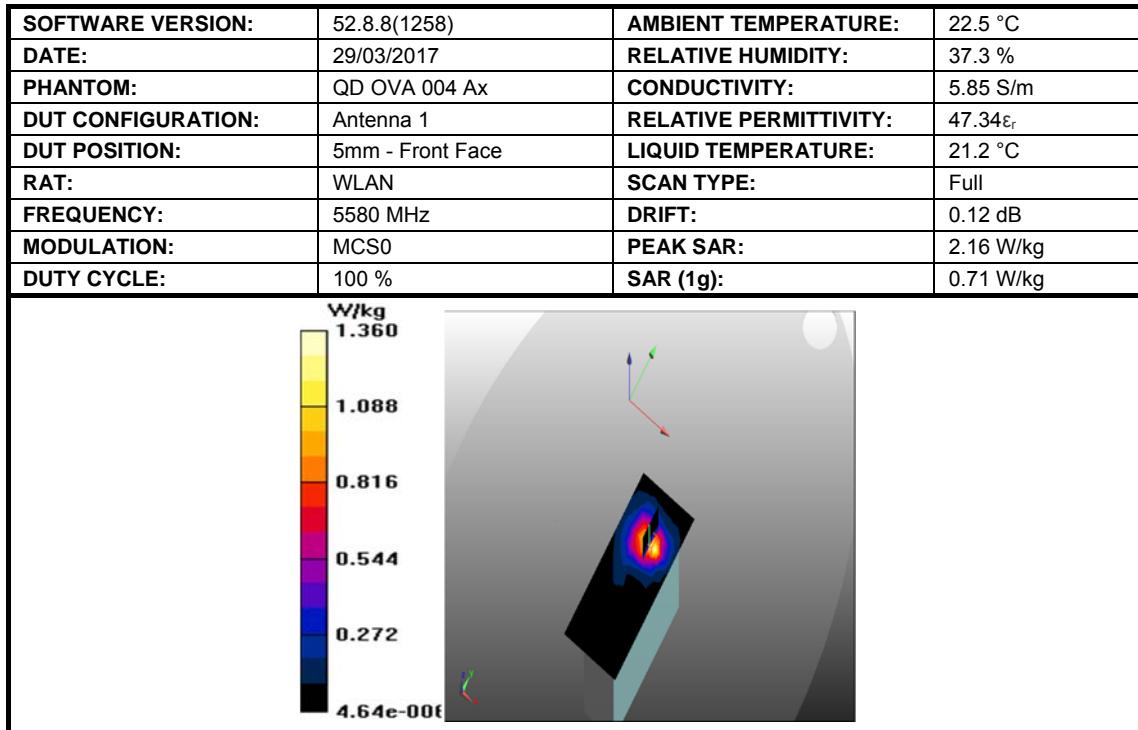


Figure 14: SAR Body Testing Results for the Echostar S55 at 5580 MHz.

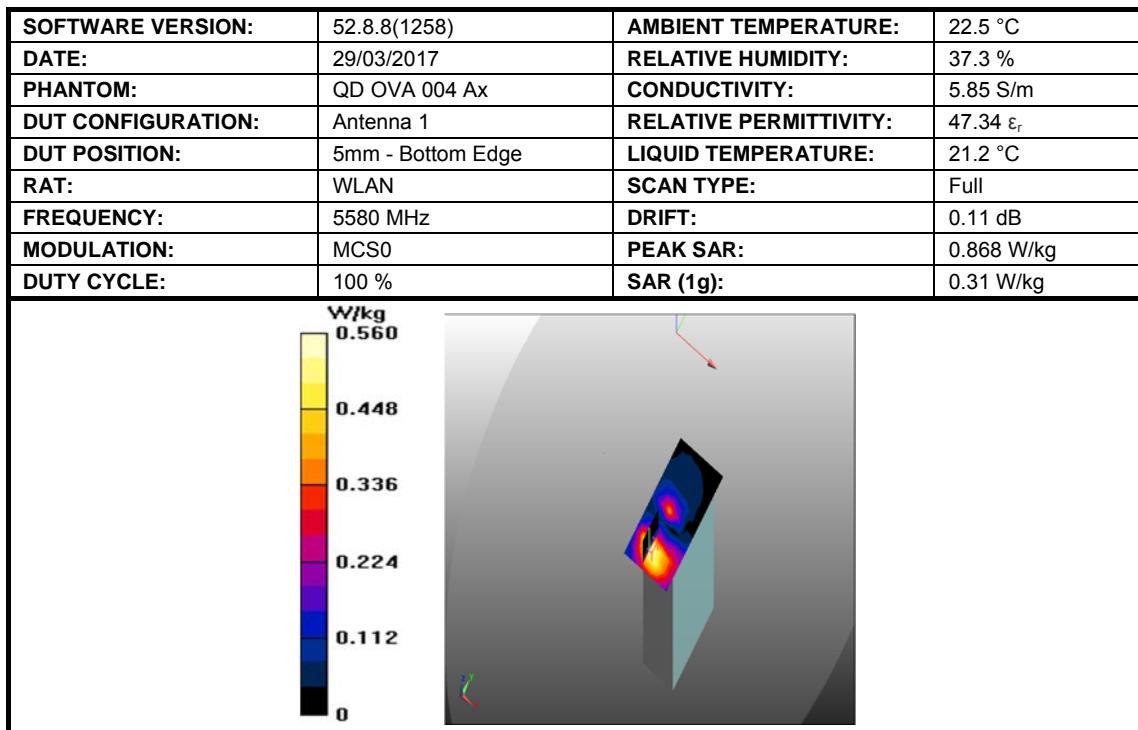


Figure 15: SAR Body Testing Results for the Echostar S55 at 5580 MHz.

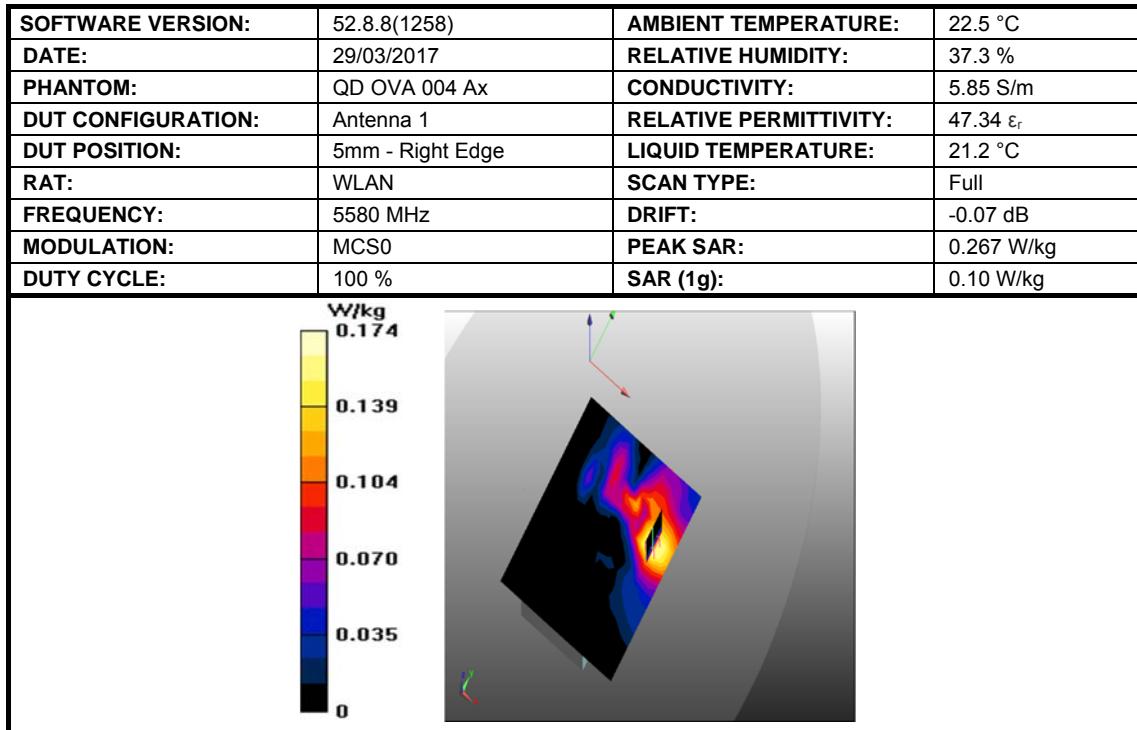


Figure 16: SAR Body Testing Results for the Echostar S55 at 5580 MHz.

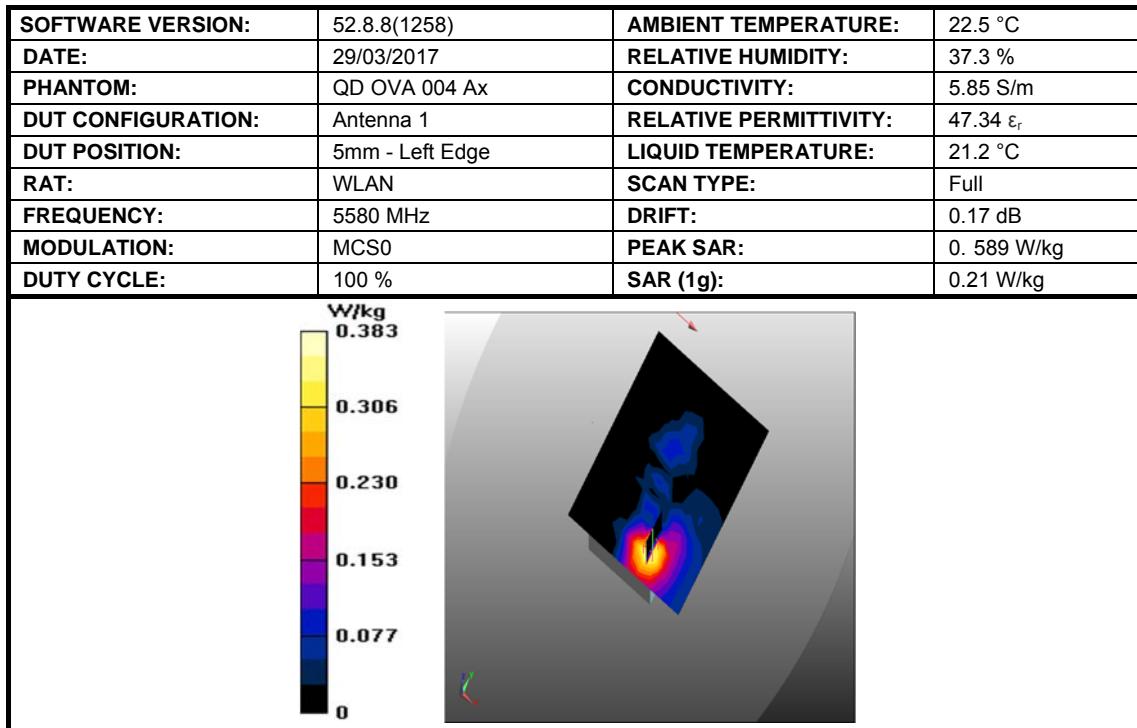


Figure 17: SAR Body Testing Results for the Echostar S55 at 5580 MHz.



2.4 WLAN U-NII-3 802.11n 40 MHz HT0 BODY SAR TEST RESULTS

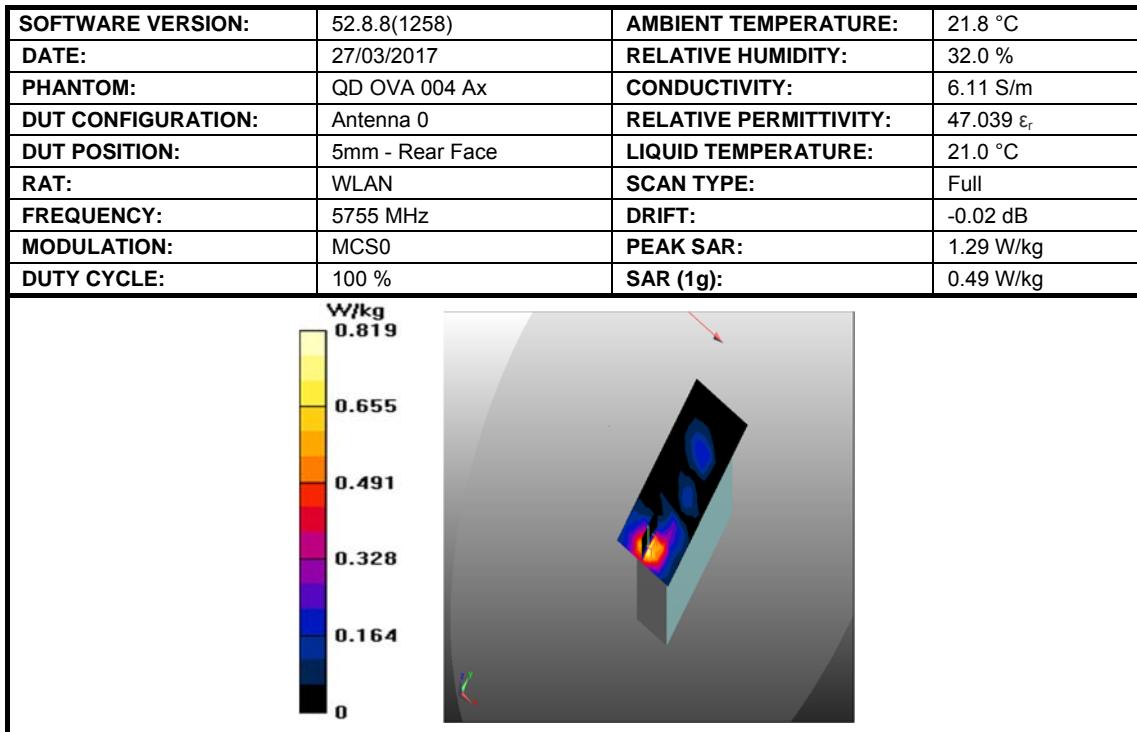


Figure 18: SAR Body Testing Results for the Echostar S55 at 5755 MHz.

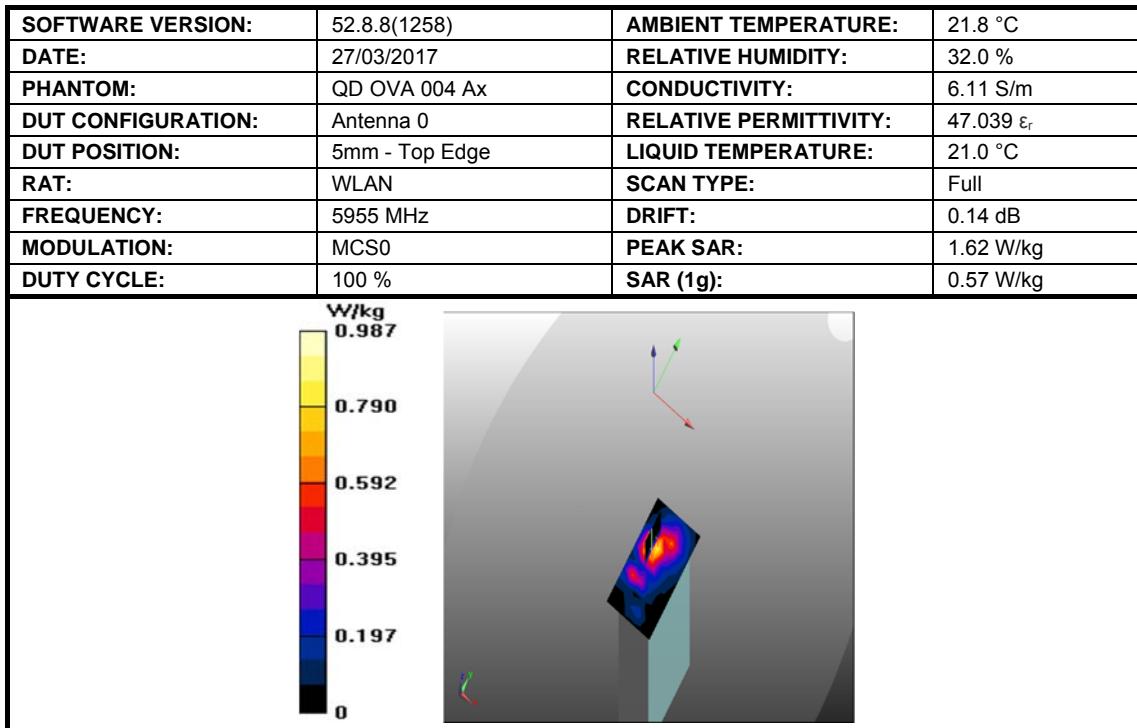


Figure 19: SAR Body Testing Results for the Echostar S55 at 5955 MHz.

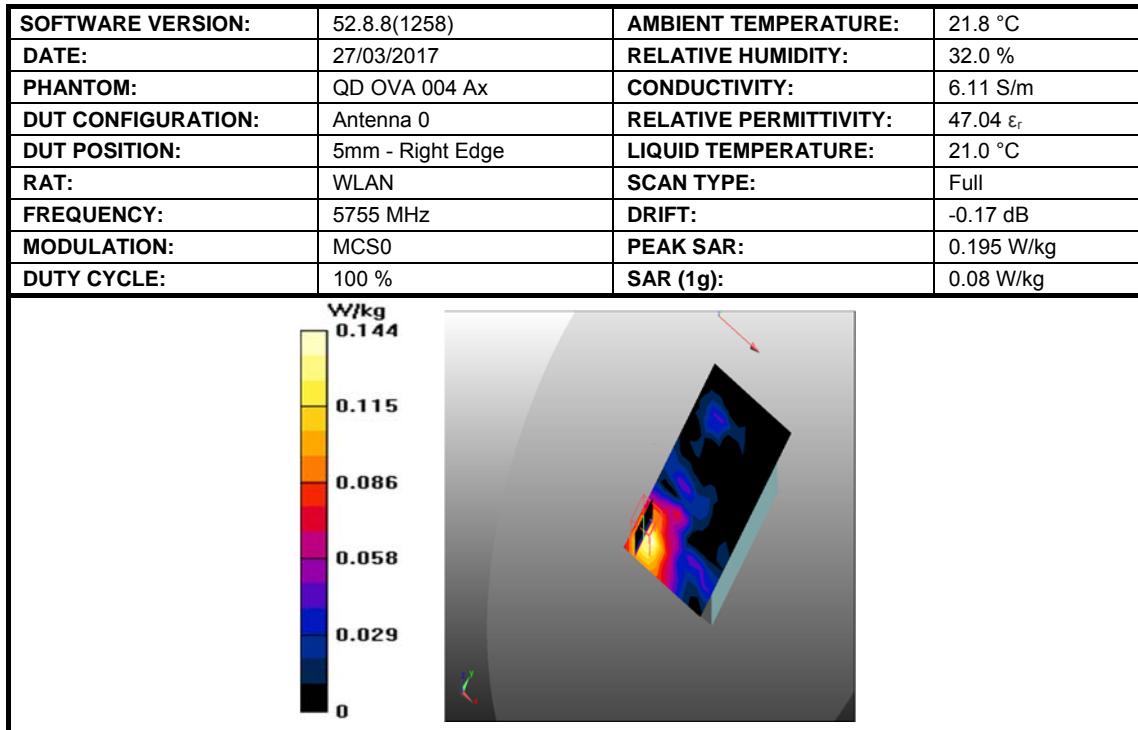


Figure 20: SAR Body Testing Results for the Echostar S55 at 5755 MHz.

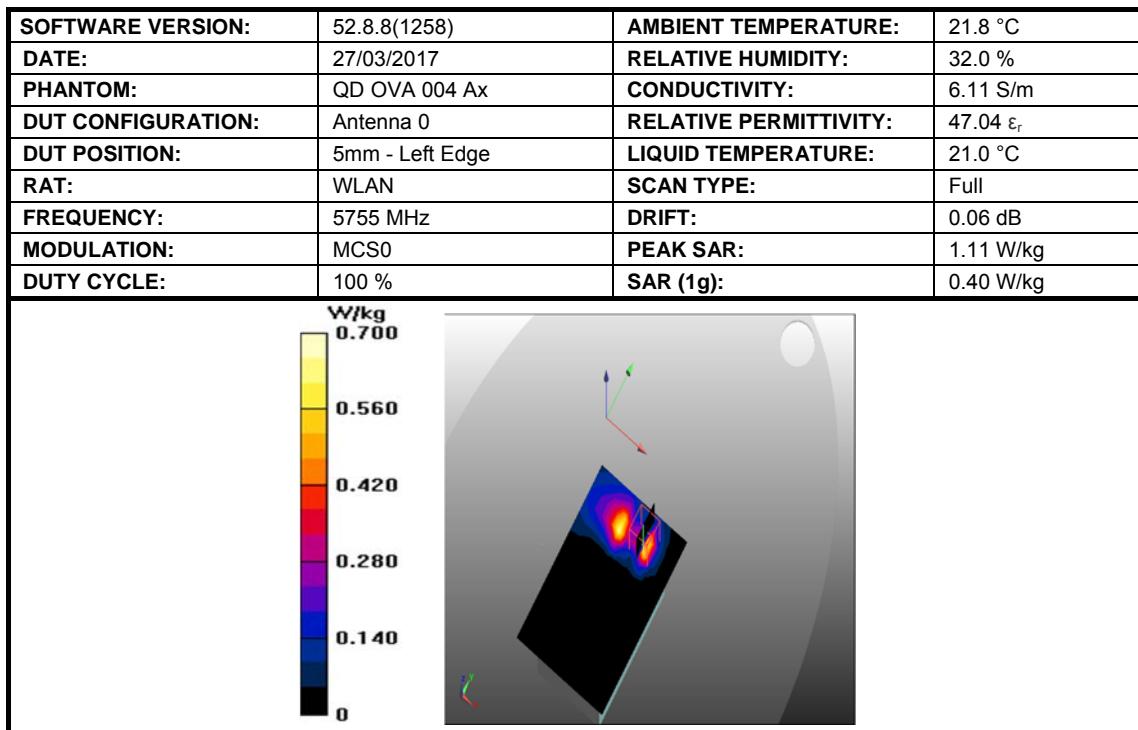


Figure 21: SAR Body Testing Results for the Echostar S55 at 5755 MHz.

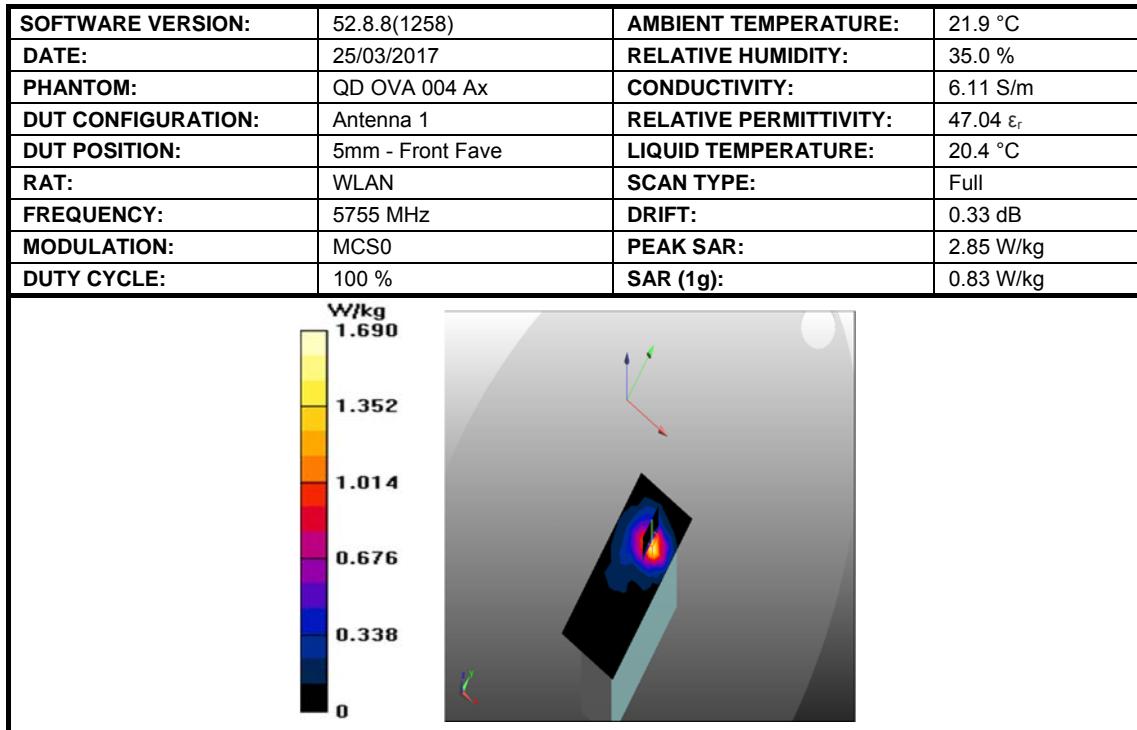


Figure 22: SAR Body Testing Results for the Echostar S55 at 5755 MHz.

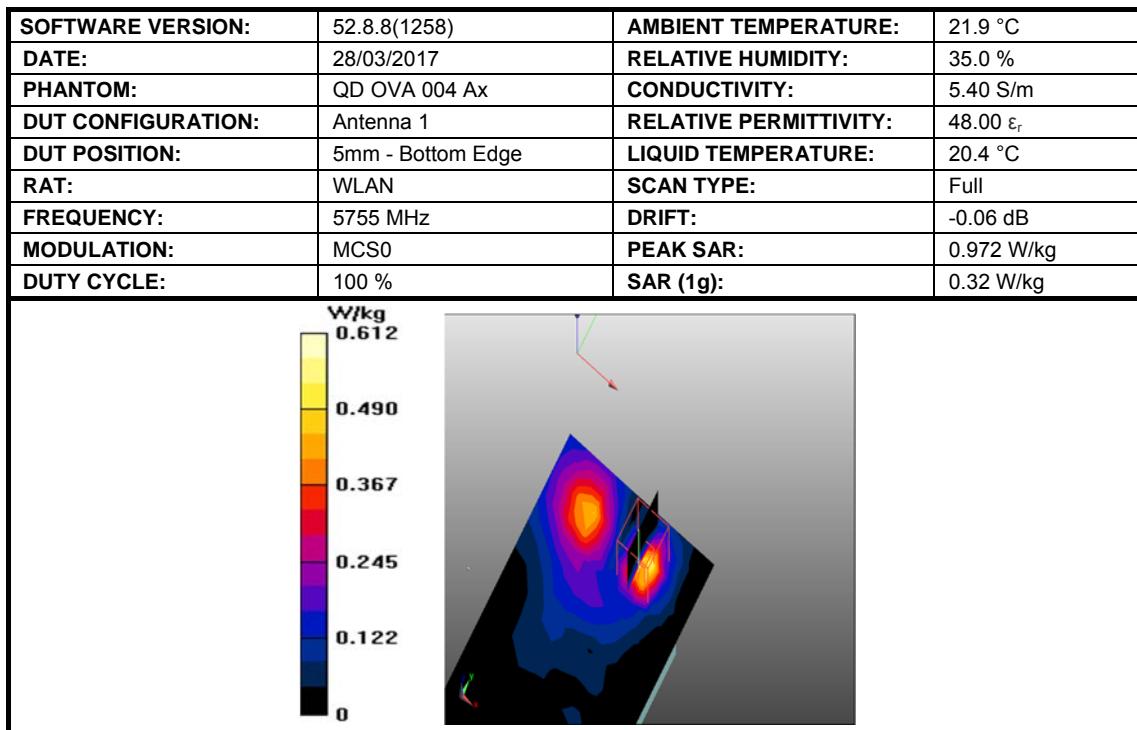


Figure 23: SAR Body Testing Results for the Echostar S55 at 5755 MHz.

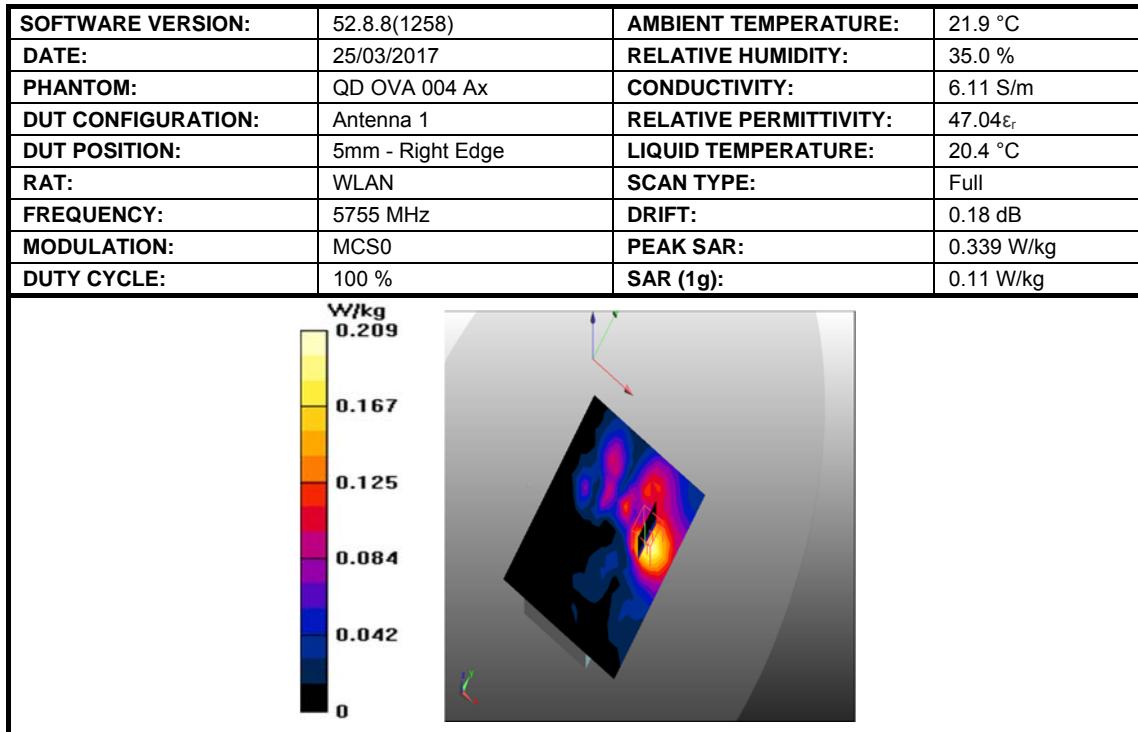


Figure 24: SAR Body Testing Results for the Echostar S55 at 5755 MHz.

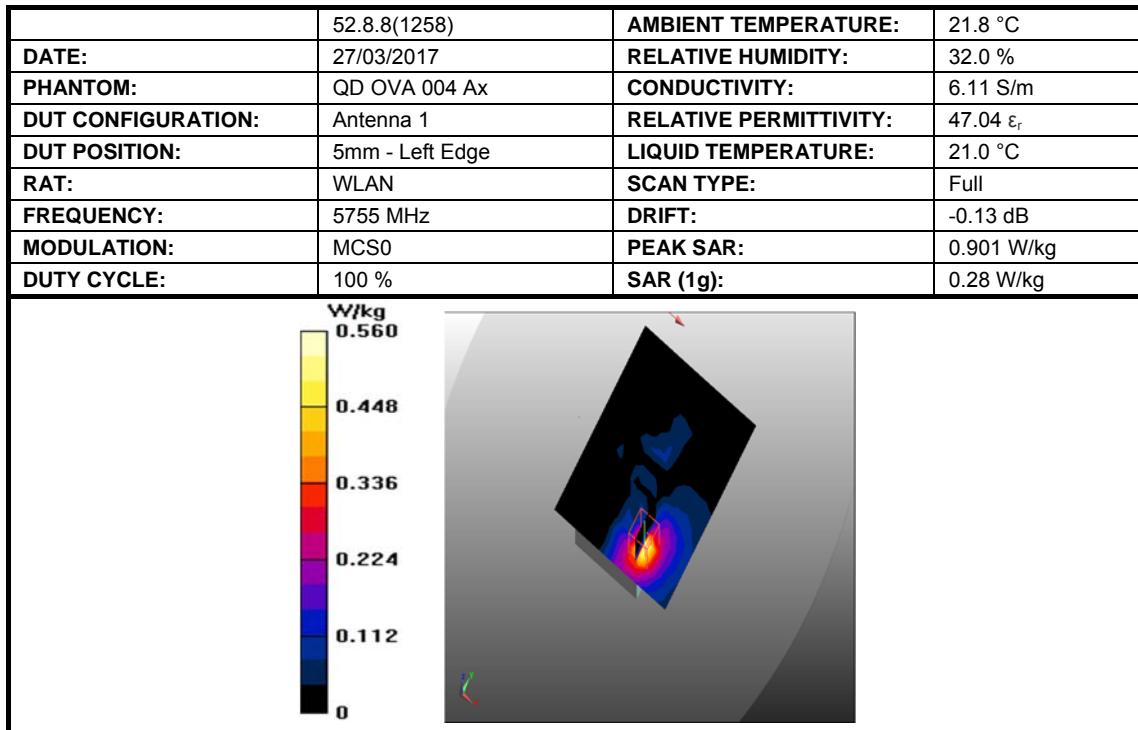


Figure 25: SAR Body Testing Results for the Echostar S55 at 5755 MHz.



Product Service

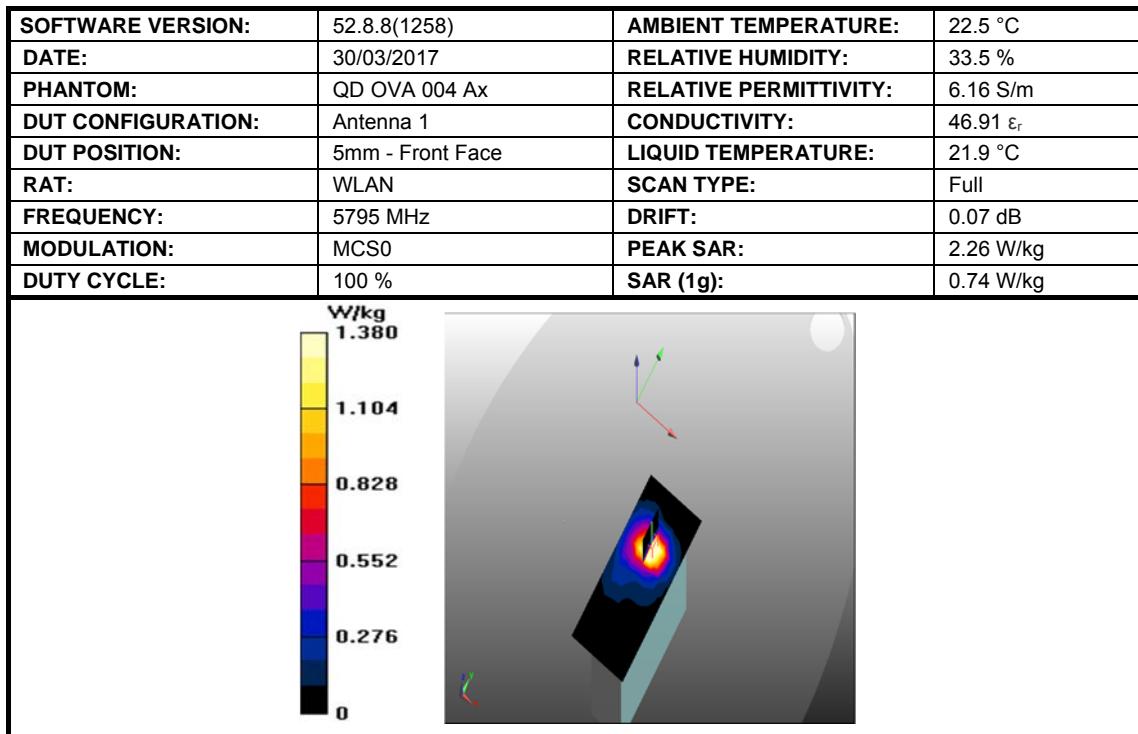


Figure 26: SAR Body Testing Results for the Echostar S55 at 5795 MHz.



Product Service

SECTION 3

TEST EQUIPMENT USED



3.1 TEST EQUIPMENT USED

The following test equipment was used at TÜV SÜD Product Service:

| Instrument Description | Manufacturer | Model Type | TE Number | Cal Period (months) | Calibration Due Date |
|---|----------------------|--|-----------|---------------------|----------------------|
| 10MHz - 2.5GHz, 3W, Amplifier | Vectawave Technology | VTL5400 | 51 | - | TU |
| Power Sensor | Rohde & Schwarz | NRV-Z1 | 60 | 12 | 16-Jun-2017 |
| Signal Generator | Hewlett Packard | ESG4000A | 61 | 12 | 12-Jul-2017 |
| Attenuator (20dB, 10W) | Weinschel | 37-20-34 | 482 | 12 | 26-Oct-2017 |
| Bi-directional Coupler | IndexSar Ltd | 7401 (VDC0830-20) | 2414 | - | TU |
| Thermometer | Digitron | T208 | 64 | 12 | 13-May-2017 |
| Hygrometer | Rotronic | I-1000 | 2784 | 12 | 26-Apr-2017 |
| Power Sensor | Rohde & Schwarz | NRV-Z5 | 2878 | 12 | 16-Jun-2017 |
| Dual Channel Power Meter | Rohde & Schwarz | NRVD | 3259 | 12 | 16-Jun-2017 |
| Data Acquisition Electronics | Speag | DAE 4 - SD 000 D04 BM | 4689 | 12 | 12-Dec-2017 |
| Measurement Server | Speag | DASY 5 Measurement Server | 4692 | - | TU |
| Body Phantom | Speag | ELI Phantom | 4699 | - | TU |
| Dosimetric SAR Probe | Speag | EX3DV4 | 4700 | 12 | 16-Dec-2017 |
| Mounting Platform for TX90XL Robot and Phantoms | Speag | MP6C-TX90XL Mounting Platform Extended | 4702 | - | TU |
| Robot | Speag | TX90 XLSpeag Robot | 4704 | - | TU |
| 5000 MHz Dipole | Speag | D5000V2 | 4796 | 12 | 14-Dec-2017 |
| MBBL Fluid | Speag | Batch 1 | N/A | Weekly | 03-Apr-2017 |

TU - Traceability Unscheduled



3.2 TEST SOFTWARE

The following software was used to control the TÜV SÜD Product Service DASY System.

| Instrument | Version Number |
|-------------|----------------|
| DASY system | 52.8.8(1258) |

3.3 DIELECTRIC PROPERTIES OF SIMULANT LIQUIDS

The fluid properties of the simulant fluids used during routine SAR evaluation meet the dielectric properties required KDB 865665.

The dielectric properties of the tissue simulant liquids used for the SAR testing at TÜV SÜD Product Service are as follows:-

| Fluid Type and Frequency | Relative Permittivity Target | Relative Permittivity Measured | Conductivity Target | Conductivity Measured |
|--------------------------|------------------------------|--------------------------------|---------------------|-----------------------|
| 5200 MHz MBBL | 49.01 | 48.10 | 5.30 | 5.29 |
| 5500 MHz MBBL | 48.61 | 47.49 | 5.65 | 5.74 |
| 5800 MHz MBBL | 48.20 | 46.90 | 6.00 | 6.16 |

3.4 TEST CONDITIONS

3.4.1 Test Laboratory Conditions

Ambient temperature: Within +15°C to +35°C.

The actual temperature during the testing ranged from 21.8°C to 22.9°C.

The actual humidity during the testing ranged from 32.0% to 37.3% RH.

3.4.2 Test Fluid Temperature Range

| Frequency | Fluid | Min Temperature °C | Max Temperature °C |
|-----------|-------|--------------------|--------------------|
| 5200 MHz | MBBL | 20.4 | 21.1 |
| 5500 MHz | MBBL | 21.1 | 21.2 |
| 5800 MHz | MBBL | 20.4 | 21.9 |

3.4.3 SAR Drift

The SAR Drift was within acceptable limits during scans. The maximum SAR Drift was recorded as 0.330 dB for Full SAR body.



3.5 MEASUREMENT UNCERTAINTY

Body, Full SAR Measurements, 3 GHz to 6 GHz Using Probe EX3DV4 - SN3759

| Source of Uncertainty | Uncertainty \pm % | Probability distribution | Div | c_i (1g) | Standard Uncertainty \pm % (1g) | $v_i (V_{eff})$ |
|--------------------------------------|---------------------|--------------------------|------|------------|-----------------------------------|-----------------|
| Measurement System | | | | | | |
| Probe calibration | 6.6 | N | 1.00 | 1.00 | 6.6 | Infinity |
| Axial Isotropy | 4.7 | R | 1.73 | 0.70 | 1.9 | Infinity |
| Hemispherical Isotropy | 9.6 | R | 1.73 | 0.70 | 3.9 | Infinity |
| Boundary effect | 2.0 | R | 1.73 | 1.00 | 1.2 | Infinity |
| Linearity | 4.7 | R | 1.73 | 1.00 | 2.7 | Infinity |
| System Detection limits | 1.0 | R | 1.73 | 1.00 | 0.6 | Infinity |
| Modulation response | 2.4 | R | 1.73 | 1.00 | 1.4 | Infinity |
| Readout electronics | 0.3 | N | 1.00 | 1.00 | 0.3 | Infinity |
| Response time | 0.8 | R | 1.73 | 1.00 | 0.5 | Infinity |
| Integration time | 2.6 | R | 1.73 | 1.00 | 1.5 | Infinity |
| RF ambient noise | 3.0 | R | 1.73 | 1.00 | 1.7 | Infinity |
| RF ambient reflections | 3.0 | R | 1.73 | 1.00 | 1.7 | Infinity |
| Probe positioner | 0.8 | R | 1.73 | 1.00 | 0.5 | Infinity |
| Probe positioning | 6.7 | R | 1.73 | 1.00 | 3.9 | Infinity |
| Max SAR Evaluation | 4.0 | R | 1.73 | 1.00 | 2.3 | Infinity |
| Test sample related | | | | | | |
| Device Positioning | 2.9 | N | 1.00 | 1.00 | 2.9 | 145 |
| Device Holder | 3.6 | N | 1.00 | 1.00 | 3.6 | 5 |
| Input Power and SAR Drift | 5.0 | R | 1.73 | 1.00 | 0.2 | Infinity |
| Phantom and Setup | | | | | | |
| Phantom uncertainty | 6.6 | R | 1.73 | 1.00 | 3.8 | Infinity |
| SAR Correction | 1.9 | R | 1.73 | 1.00 | 1.1 | Infinity |
| Liquid conductivity Meas. | 2.5 | R | 1.73 | 0.78 | 1.1 | Infinity |
| Liquid Permittivity Meas. | 2.5 | R | 1.73 | 0.23 | 0.3 | Infinity |
| Temp. Unc. Conductivity | 3.4 | R | 1.73 | 0.78 | 1.5 | Infinity |
| Temp. Unc. Permittivity | 0.4 | R | 1.73 | 0.23 | 0.1 | Infinity |
| Combined Standard Uncertainty | RSS | | | | 11.9 | 748 |
| Expanded Standard Uncertainty | K=2 | | | | 23.9 | |



Product Service

SECTION 4

ACCREDITATION, DISCLAIMERS AND COPYRIGHT



Product Service

4.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT



This report relates only to the actual item/items tested.

Our UKAS Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our UKAS Accreditation.

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TÜV SÜD Product Service

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Product Service

ANNEX A

PROBE CALIBRATION REPORT



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



S Schweizerischer Kalibrierdienst
C Service suisse d'étalementage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
 The Swiss Accreditation Service is one of the signatories to the EA
 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**Client **TÜV SÜD UK**Certificate No: **EX3-3759_Dec16**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3759**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v4, QA CAL-23.v5,
 QA CAL-25.v6
 Calibration procedure for dosimetric E-field probes**

Calibration date: **December 16, 2016**

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 |
|----------------------------|------------------|-----------------------------------|------------------------|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 05-Apr-16 (No. 217-02293) | Apr-17 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-15 (No. ES3-3013_Dec15) | Dec-16 |
| DAE4 | SN: 660 | 7-Dec-16 (No. DAE4-660_Dec16) | Dec-17 |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Jun-16) | In house check: Jun-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-16) | In house check: Oct-17 |

| | | | |
|----------------|------------------------------|--|-----------|
| Calibrated by: | Name Michael Weber | Function Laboratory Technician | Signature |
| Approved by: | Name Katja Pokovic | Function Technical Manager | |

Issued: December 19, 2016

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



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



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
 The Swiss Accreditation Service is one of the signatories to the EA
 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108****Glossary:**

| | |
|--------------------------|--|
| TSL | tissue simulating liquid |
| NORM _{x,y,z} | sensitivity in free space |
| ConvF | sensitivity in TSL / NORM _{x,y,z} |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}:** Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E-field uncertainty inside TSL (see below *ConvF*).
- NORM(f)_{x,y,z} = NORM_{x,y,z} * frequency_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- DCPx,y,z:** DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR:** PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}:** A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters:** Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to $NORM_{x,y,z} * ConvF$ whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy):** in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset:** The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle:** The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).



Product Service

EX3DV4 – SN:3759

December 16, 2016

Probe EX3DV4

SN:3759

Manufactured: March 16, 2010
Calibrated: December 16, 2016

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)



EX3DV4- SN:3759

December 16, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3759

Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|------------------------------------|----------|----------|----------|---------------|
| Norm (μ V/(V/m)) ^A | 0.47 | 0.42 | 0.45 | $\pm 10.1 \%$ |
| DCP (mV) ^B | 101.1 | 99.1 | 101.2 | |

Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB $\sqrt{\mu}$ V | C | D dB | VR mV | Unc ^E (k=2) |
|-----|---------------------------|---|---------|------------------------|-----|---------|----------|---------------------------|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 149.0 | $\pm 3.5 \%$ |
| | | Y | 0.0 | 0.0 | 1.0 | | 147.4 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 138.4 | |

Note: For details on UID parameters see Appendix.

Sensor Model Parameters

| | C1 fF | C2 fF | α V ⁻¹ | T1 ms.V ⁻² | T2 ms.V ⁻¹ | T3 ms | T4 V ⁻² | T5 V ⁻¹ | T6 |
|---|----------|----------|-----------------------------|--------------------------|--------------------------|----------|-----------------------|-----------------------|-------|
| X | 45.34 | 339.8 | 35.83 | 13.18 | 1.015 | 4.992 | 0.942 | 0.363 | 1.005 |
| Y | 51.23 | 384.3 | 35.89 | 14.75 | 0.946 | 5.017 | 1.083 | 0.33 | 1.006 |
| Z | 48.36 | 361.1 | 35.6 | 14.31 | 1.297 | 4.99 | 0.629 | 0.453 | 1.004 |

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%.

^A The uncertainties of Norm X,Y,Z do not affect the E²-field uncertainty inside TSL (see Pages 5 and 6).

^B Numerical linearization parameter: uncertainty not required.

^E Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.



EX3DV4- SN:3759

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3759

Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) ^C | Relative Permittivity ^F | Conductivity (S/m) ^F | ConvF X | ConvF Y | ConvF Z | Alpha ^G | Depth ^G (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 450 | 43.5 | 0.87 | 10.95 | 10.95 | 10.95 | 0.15 | 1.30 | ± 13.3 % |
| 750 | 41.9 | 0.89 | 10.45 | 10.45 | 10.45 | 0.28 | 1.01 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 10.04 | 10.04 | 10.04 | 0.16 | 1.40 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 9.94 | 9.94 | 9.94 | 0.24 | 0.97 | ± 12.0 % |
| 1640 | 40.3 | 1.29 | 8.63 | 8.63 | 8.63 | 0.19 | 0.80 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 8.58 | 8.58 | 8.58 | 0.18 | 0.96 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 8.32 | 8.32 | 8.32 | 0.14 | 0.86 | ± 12.0 % |
| 2100 | 39.8 | 1.49 | 8.45 | 8.45 | 8.45 | 0.23 | 0.84 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 7.80 | 7.80 | 7.80 | 0.15 | 1.07 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 7.42 | 7.42 | 7.42 | 0.23 | 0.86 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 7.16 | 7.16 | 7.16 | 0.20 | 1.08 | ± 12.0 % |
| 5200 | 36.0 | 4.66 | 5.68 | 5.68 | 5.68 | 0.30 | 1.80 | ± 13.1 % |
| 5300 | 35.9 | 4.76 | 5.46 | 5.46 | 5.46 | 0.30 | 1.80 | ± 13.1 % |
| 5500 | 35.6 | 4.96 | 5.05 | 5.05 | 5.05 | 0.35 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.72 | 4.72 | 4.72 | 0.40 | 1.80 | ± 13.1 % |
| 5800 | 35.3 | 5.27 | 5.02 | 5.02 | 5.02 | 0.40 | 1.80 | ± 13.1 % |

^C Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.



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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3759

Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) ^C | Relative Permittivity ^F | Conductivity (S/m) ^F | ConvF X | ConvF Y | ConvF Z | Alpha ^G | Depth ^G (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 450 | 56.7 | 0.94 | 11.67 | 11.67 | 11.67 | 0.05 | 1.20 | ± 13.3 % |
| 750 | 55.5 | 0.96 | 10.25 | 10.25 | 10.25 | 0.31 | 0.85 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 9.85 | 9.85 | 9.85 | 0.16 | 1.31 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 9.83 | 9.83 | 9.83 | 0.29 | 0.86 | ± 12.0 % |
| 1640 | 53.8 | 1.40 | 8.63 | 8.63 | 8.63 | 0.26 | 0.80 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 8.16 | 8.16 | 8.16 | 0.27 | 0.86 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 7.87 | 7.87 | 7.87 | 0.21 | 0.96 | ± 12.0 % |
| 2100 | 53.2 | 1.62 | 8.26 | 8.26 | 8.26 | 0.16 | 1.04 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 7.56 | 7.56 | 7.56 | 0.29 | 0.80 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 7.49 | 7.49 | 7.49 | 0.11 | 0.99 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 7.31 | 7.31 | 7.31 | 0.14 | 1.10 | ± 12.0 % |
| 5200 | 49.0 | 5.30 | 5.00 | 5.00 | 5.00 | 0.35 | 1.90 | ± 13.1 % |
| 5300 | 48.9 | 5.42 | 4.78 | 4.78 | 4.78 | 0.35 | 1.90 | ± 13.1 % |
| 5500 | 48.6 | 5.65 | 4.27 | 4.27 | 4.27 | 0.40 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 3.98 | 3.98 | 3.98 | 0.50 | 1.90 | ± 13.1 % |
| 5800 | 48.2 | 6.00 | 4.20 | 4.20 | 4.20 | 0.50 | 1.90 | ± 13.1 % |

^C Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.



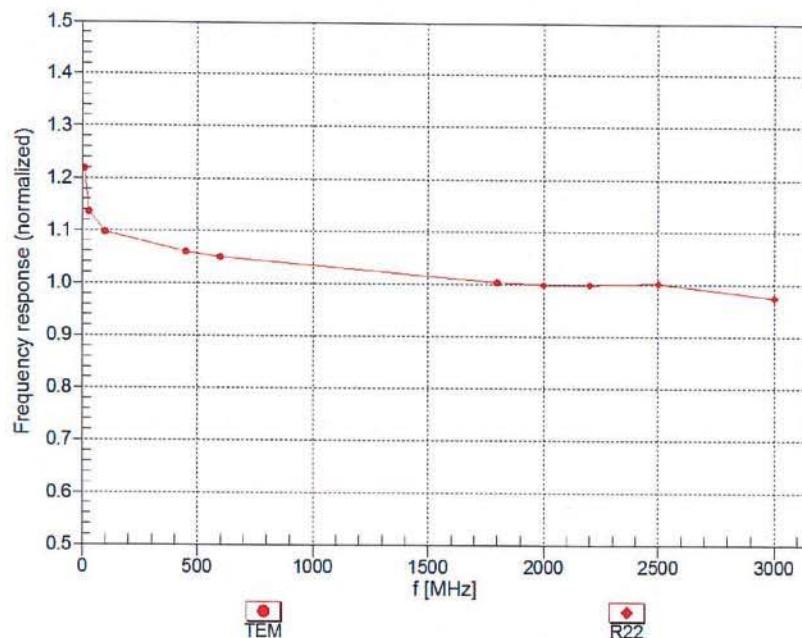
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Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide: R22)

Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)



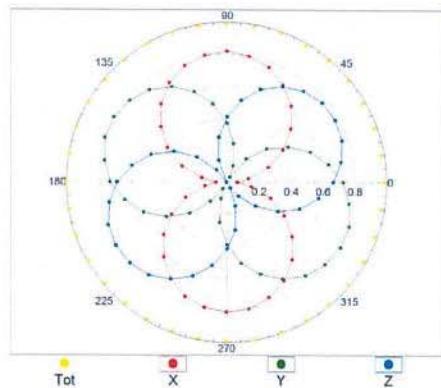
Product Service

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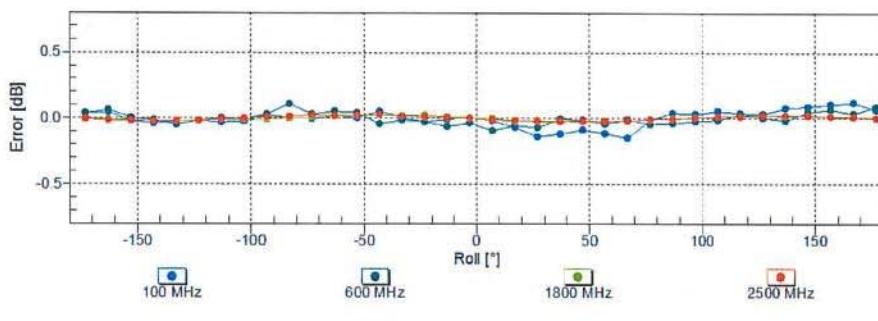
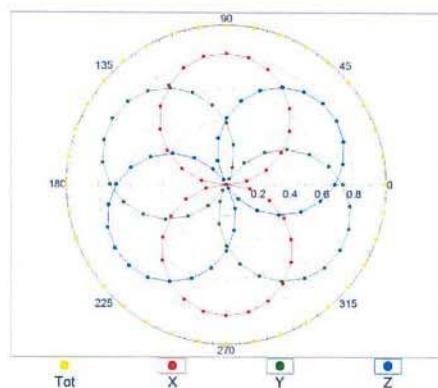
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Receiving Pattern (ϕ), $\theta = 0^\circ$

f=600 MHz, TEM



f=1800 MHz, R22

Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)

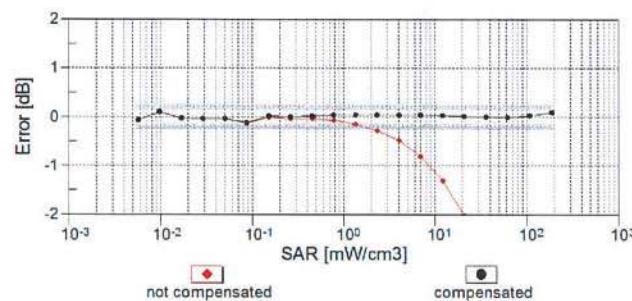
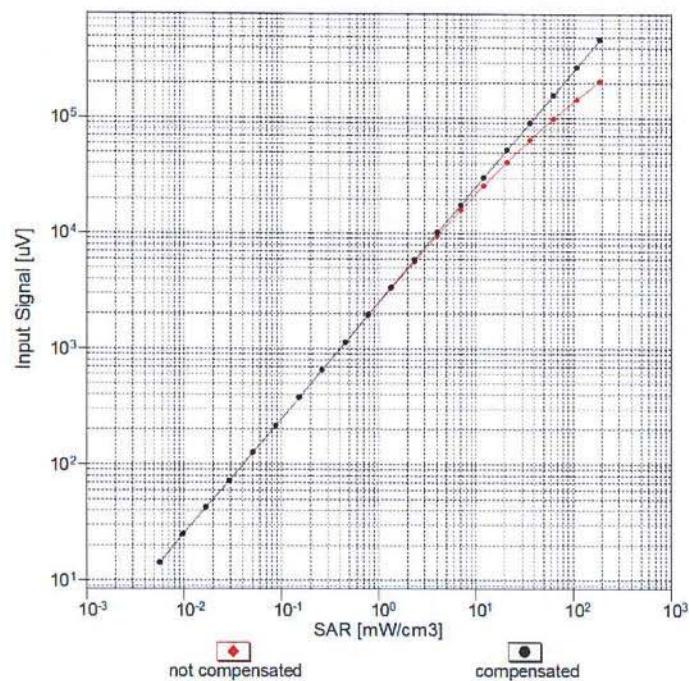


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Dynamic Range f(SAR_{head})
(TEM cell , f_{eval}= 1900 MHz)



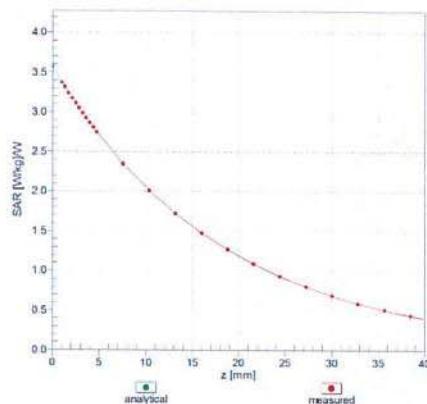
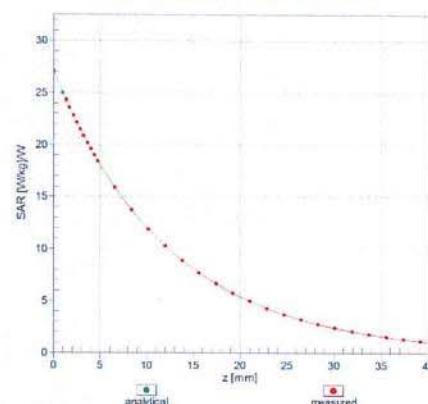
Uncertainty of Linearity Assessment: ± 0.6% (k=2)



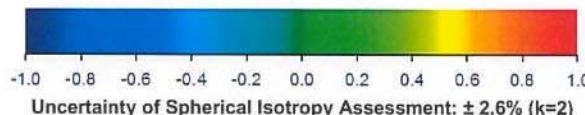
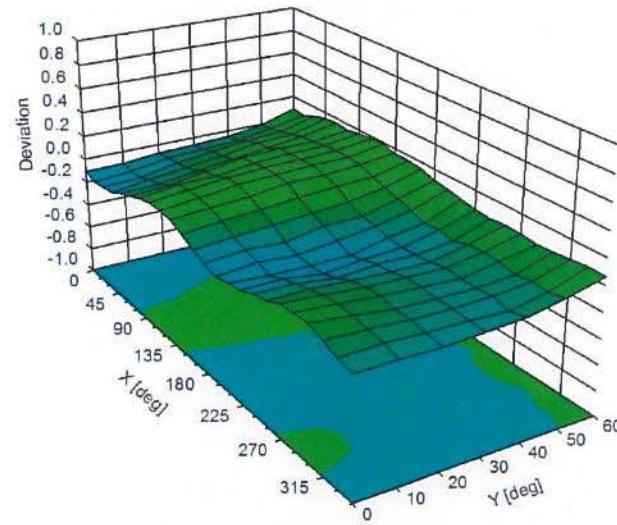
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Conversion Factor Assessment

 $f = 900 \text{ MHz}, \text{WGLS R9 (H_convF)}$  $f = 1750 \text{ MHz}, \text{WGLS R22 (H_convF)}$ 

Deviation from Isotropy in Liquid

Error (ϕ, θ), $f = 900 \text{ MHz}$ Uncertainty of Spherical Isotropy Assessment: $\pm 2.6\% \text{ (k=2)}$



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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3759

Other Probe Parameters

| | |
|---|------------|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -3 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 9 mm |
| Tip Diameter | 2.5 mm |
| Probe Tip to Sensor X Calibration Point | 1 mm |
| Probe Tip to Sensor Y Calibration Point | 1 mm |
| Probe Tip to Sensor Z Calibration Point | 1 mm |
| Recommended Measurement Distance from Surface | 1.4 mm |



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Appendix: Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB/ μ V | C | D dB | VR mV | Max Unc ^E (k=2) |
|-----------|---|---|---------|------------------|-------|---------|----------|----------------------------------|
| 0 | CW | X | 0.00 | 0.00 | 1.00 | 0.00 | 149.0 | $\pm 3.5\%$ |
| | | Y | 0.00 | 0.00 | 1.00 | | 147.4 | |
| | | Z | 0.00 | 0.00 | 1.00 | | 138.4 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 3.04 | 67.74 | 11.79 | 10.00 | 20.0 | $\pm 9.6\%$ |
| | | Y | 3.27 | 68.79 | 12.30 | | 20.0 | |
| | | Z | 3.42 | 68.76 | 12.60 | | 20.0 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 0.99 | 66.30 | 14.68 | 0.00 | 150.0 | $\pm 9.6\%$ |
| | | Y | 1.02 | 66.67 | 14.90 | | 150.0 | |
| | | Z | 0.99 | 66.23 | 14.64 | | 150.0 | |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 1.17 | 63.37 | 14.79 | 0.41 | 150.0 | $\pm 9.6\%$ |
| | | Y | 1.18 | 63.58 | 14.98 | | 150.0 | |
| | | Z | 1.18 | 63.40 | 14.78 | | 150.0 | |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 4.83 | 66.46 | 16.84 | 1.46 | 150.0 | $\pm 9.6\%$ |
| | | Y | 4.90 | 66.50 | 16.94 | | 150.0 | |
| | | Z | 4.87 | 66.45 | 16.82 | | 150.0 | |
| 10021-DAC | GSM-FDD (TDMA, GMSK) | X | 27.32 | 96.15 | 23.00 | 9.39 | 50.0 | $\pm 9.6\%$ |
| | | Y | 100.00 | 113.48 | 27.55 | | 50.0 | |
| | | Z | 18.13 | 91.34 | 22.13 | | 50.0 | |
| 10023-DAC | GPRS-FDD (TDMA, GMSK, TN 0) | X | 17.75 | 90.44 | 21.39 | 9.57 | 50.0 | $\pm 9.6\%$ |
| | | Y | 64.93 | 107.78 | 26.22 | | 50.0 | |
| | | Z | 13.93 | 87.63 | 21.03 | | 50.0 | |
| 10024-DAC | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 100.00 | 110.23 | 24.91 | 6.56 | 60.0 | $\pm 9.6\%$ |
| | | Y | 100.00 | 111.43 | 25.52 | | 60.0 | |
| | | Z | 66.71 | 106.54 | 24.55 | | 60.0 | |
| 10025-DAC | EDGE-FDD (TDMA, 8PSK, TN 0) | X | 4.69 | 70.97 | 25.39 | 12.57 | 50.0 | $\pm 9.6\%$ |
| | | Y | 9.43 | 92.86 | 36.24 | | 50.0 | |
| | | Z | 4.57 | 69.11 | 24.07 | | 50.0 | |
| 10026-DAC | EDGE-FDD (TDMA, 8PSK, TN 0-1) | X | 8.47 | 87.67 | 30.15 | 9.56 | 60.0 | $\pm 9.6\%$ |
| | | Y | 11.37 | 95.44 | 33.46 | | 60.0 | |
| | | Z | 8.88 | 87.57 | 29.82 | | 60.0 | |
| 10027-DAC | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 100.00 | 109.77 | 23.94 | 4.80 | 80.0 | $\pm 9.6\%$ |
| | | Y | 100.00 | 111.14 | 24.62 | | 80.0 | |
| | | Z | 100.00 | 110.40 | 24.46 | | 80.0 | |
| 10028-DAC | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 100.00 | 110.50 | 23.60 | 3.55 | 100.0 | $\pm 9.6\%$ |
| | | Y | 100.00 | 111.94 | 24.31 | | 100.0 | |
| | | Z | 100.00 | 110.79 | 23.94 | | 100.0 | |
| 10029-DAC | EDGE-FDD (TDMA, 8PSK, TN 0-1-2) | X | 5.65 | 79.24 | 25.77 | 7.80 | 80.0 | $\pm 9.6\%$ |
| | | Y | 6.78 | 83.68 | 27.89 | | 80.0 | |
| | | Z | 6.05 | 79.84 | 25.79 | | 80.0 | |
| 10030-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH1) | X | 100.00 | 108.40 | 23.61 | 5.30 | 70.0 | $\pm 9.6\%$ |
| | | Y | 100.00 | 109.85 | 24.34 | | 70.0 | |
| | | Z | 39.21 | 99.31 | 21.96 | | 70.0 | |
| 10031-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH3) | X | 100.00 | 109.64 | 22.00 | 1.88 | 100.0 | $\pm 9.6\%$ |
| | | Y | 100.00 | 111.22 | 22.73 | | 100.0 | |
| | | Z | 100.00 | 109.98 | 22.33 | | 100.0 | |



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| | | | | | | | | |
|-----------|---|---|--------|--------|-------|-------|-------|---------|
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 100.00 | 115.35 | 23.50 | 1.17 | 100.0 | ± 9.6 % |
| | | Y | 100.00 | 116.40 | 23.97 | | 100.0 | |
| | | Z | 100.00 | 114.90 | 23.50 | | 100.0 | |
| 10033-CAA | IEEE 802.15.1 Bluetooth (PI/4-DQPSK, DH1) | X | 5.50 | 80.43 | 20.01 | 5.30 | 70.0 | ± 9.6 % |
| | | Y | 8.78 | 88.43 | 23.32 | | 70.0 | |
| | | Z | 5.52 | 79.91 | 19.94 | | 70.0 | |
| 10034-CAA | IEEE 802.15.1 Bluetooth (PI/4-DQPSK, DH3) | X | 2.26 | 72.05 | 15.71 | 1.88 | 100.0 | ± 9.6 % |
| | | Y | 2.75 | 75.11 | 17.48 | | 100.0 | |
| | | Z | 2.35 | 72.23 | 15.94 | | 100.0 | |
| 10035-CAA | IEEE 802.15.1 Bluetooth (PI/4-DQPSK, DH5) | X | 1.71 | 69.83 | 14.64 | 1.17 | 100.0 | ± 9.6 % |
| | | Y | 1.95 | 71.69 | 15.93 | | 100.0 | |
| | | Z | 1.77 | 69.99 | 14.88 | | 100.0 | |
| 10036-CAA | IEEE 802.15.1 Bluetooth (8-DPSK, DH1) | X | 6.42 | 82.93 | 20.96 | 5.30 | 70.0 | ± 9.6 % |
| | | Y | 11.14 | 92.31 | 24.62 | | 70.0 | |
| | | Z | 6.34 | 82.16 | 20.81 | | 70.0 | |
| 10037-CAA | IEEE 802.15.1 Bluetooth (8-DPSK, DH3) | X | 2.14 | 71.45 | 15.43 | 1.88 | 100.0 | ± 9.6 % |
| | | Y | 2.61 | 74.51 | 17.21 | | 100.0 | |
| | | Z | 2.24 | 71.69 | 15.69 | | 100.0 | |
| 10038-CAA | IEEE 802.15.1 Bluetooth (8-DPSK, DH5) | X | 1.72 | 70.07 | 14.85 | 1.17 | 100.0 | ± 9.6 % |
| | | Y | 1.96 | 72.01 | 16.17 | | 100.0 | |
| | | Z | 1.78 | 70.24 | 15.09 | | 100.0 | |
| 10039-CAB | CDMA2000 (1xRTT, RC1) | X | 1.67 | 70.78 | 15.04 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 1.78 | 71.15 | 15.56 | | 150.0 | |
| | | Z | 1.72 | 70.94 | 15.32 | | 150.0 | |
| 10042-CAB | IS-54 / IS-136 FDD (TDMA/FDM, PI/4-DQPSK, Halfrate) | X | 22.45 | 92.22 | 20.50 | 7.78 | 50.0 | ± 9.6 % |
| | | Y | 100.00 | 109.74 | 25.02 | | 50.0 | |
| | | Z | 17.06 | 89.50 | 20.18 | | 50.0 | |
| 10044-CAA | IS-91/EIA/TIA-553 FDD (FDMA, FM) | X | 0.00 | 92.98 | 2.04 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 0.00 | 94.50 | 2.19 | | 150.0 | |
| | | Z | 0.00 | 94.03 | 3.01 | | 150.0 | |
| 10048-CAA | DECT (TDD, TDMA/FDM, GFSK, Full Slot, 24) | X | 8.86 | 78.37 | 18.88 | 13.80 | 25.0 | ± 9.6 % |
| | | Y | 12.87 | 84.32 | 21.06 | | 25.0 | |
| | | Z | 8.56 | 78.04 | 19.28 | | 25.0 | |
| 10049-CAA | DECT (TDD, TDMA/FDM, GFSK, Double Slot, 12) | X | 9.63 | 81.59 | 18.85 | 10.79 | 40.0 | ± 9.6 % |
| | | Y | 15.92 | 88.85 | 21.37 | | 40.0 | |
| | | Z | 9.22 | 81.13 | 19.17 | | 40.0 | |
| 10056-CAA | UMTS-TDD (TD-SCDMA, 1.28 Mcps) | X | 9.68 | 84.10 | 21.63 | 9.03 | 50.0 | ± 9.6 % |
| | | Y | 14.40 | 91.26 | 24.48 | | 50.0 | |
| | | Z | 8.89 | 82.35 | 21.22 | | 50.0 | |
| 10058-DAC | EDGE-FDD (TDMA, 8PSK, TN 0-1-2-3) | X | 4.44 | 74.95 | 23.28 | 6.55 | 100.0 | ± 9.6 % |
| | | Y | 5.07 | 77.93 | 24.80 | | 100.0 | |
| | | Z | 4.74 | 75.63 | 23.39 | | 100.0 | |
| 10059-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 2 Mbps) | X | 1.20 | 64.26 | 15.22 | 0.61 | 110.0 | ± 9.6 % |
| | | Y | 1.22 | 64.64 | 15.52 | | 110.0 | |
| | | Z | 1.22 | 64.34 | 15.22 | | 110.0 | |
| 10060-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 5.5 Mbps) | X | 3.05 | 83.81 | 21.08 | 1.30 | 110.0 | ± 9.6 % |
| | | Y | 6.45 | 94.80 | 24.64 | | 110.0 | |
| | | Z | 3.16 | 83.51 | 20.82 | | 110.0 | |

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| | | | | | | | | |
|-----------|--|---|------|-------|-------|------|-------|---------|
| 10061-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps) | X | 2.26 | 74.64 | 19.29 | 2.04 | 110.0 | ± 9.6 % |
| | | Y | 2.80 | 78.34 | 20.99 | | 110.0 | |
| | | Z | 2.40 | 74.91 | 19.27 | | 110.0 | |
| 10062-CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps) | X | 4.64 | 66.51 | 16.35 | 0.49 | 100.0 | ± 9.6 % |
| | | Y | 4.71 | 66.52 | 16.41 | | 100.0 | |
| | | Z | 4.68 | 66.50 | 16.34 | | 100.0 | |
| 10063-CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 9 Mbps) | X | 4.65 | 66.58 | 16.42 | 0.72 | 100.0 | ± 9.6 % |
| | | Y | 4.72 | 66.60 | 16.50 | | 100.0 | |
| | | Z | 4.69 | 66.57 | 16.41 | | 100.0 | |
| 10064-CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 12 Mbps) | X | 4.93 | 66.82 | 16.63 | 0.86 | 100.0 | ± 9.6 % |
| | | Y | 5.02 | 66.89 | 16.73 | | 100.0 | |
| | | Z | 4.98 | 66.83 | 16.63 | | 100.0 | |
| 10065-CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 18 Mbps) | X | 4.80 | 66.69 | 16.70 | 1.21 | 100.0 | ± 9.6 % |
| | | Y | 4.89 | 66.77 | 16.81 | | 100.0 | |
| | | Z | 4.84 | 66.71 | 16.69 | | 100.0 | |
| 10066-CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 24 Mbps) | X | 4.81 | 66.69 | 16.83 | 1.46 | 100.0 | ± 9.6 % |
| | | Y | 4.90 | 66.80 | 16.97 | | 100.0 | |
| | | Z | 4.86 | 66.71 | 16.83 | | 100.0 | |
| 10067-CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 36 Mbps) | X | 5.10 | 66.85 | 17.25 | 2.04 | 100.0 | ± 9.6 % |
| | | Y | 5.19 | 66.91 | 17.37 | | 100.0 | |
| | | Z | 5.15 | 66.85 | 17.23 | | 100.0 | |
| 10068-CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 48 Mbps) | X | 5.14 | 66.87 | 17.43 | 2.55 | 100.0 | ± 9.6 % |
| | | Y | 5.25 | 67.04 | 17.62 | | 100.0 | |
| | | Z | 5.21 | 66.92 | 17.43 | | 100.0 | |
| 10069-CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 54 Mbps) | X | 5.22 | 66.88 | 17.62 | 2.67 | 100.0 | ± 9.6 % |
| | | Y | 5.33 | 67.01 | 17.80 | | 100.0 | |
| | | Z | 5.29 | 66.91 | 17.62 | | 100.0 | |
| 10071-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 9 Mbps) | X | 4.92 | 66.52 | 17.10 | 1.99 | 100.0 | ± 9.6 % |
| | | Y | 4.99 | 66.58 | 17.23 | | 100.0 | |
| | | Z | 4.96 | 66.52 | 17.09 | | 100.0 | |
| 10072-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 12 Mbps) | X | 4.90 | 66.80 | 17.28 | 2.30 | 100.0 | ± 9.6 % |
| | | Y | 4.98 | 66.91 | 17.43 | | 100.0 | |
| | | Z | 4.95 | 66.83 | 17.27 | | 100.0 | |
| 10073-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 18 Mbps) | X | 4.96 | 66.95 | 17.56 | 2.83 | 100.0 | ± 9.6 % |
| | | Y | 5.04 | 67.07 | 17.74 | | 100.0 | |
| | | Z | 5.01 | 66.98 | 17.56 | | 100.0 | |
| 10074-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 24 Mbps) | X | 4.95 | 66.85 | 17.70 | 3.30 | 100.0 | ± 9.6 % |
| | | Y | 5.02 | 66.97 | 17.89 | | 100.0 | |
| | | Z | 5.01 | 66.89 | 17.70 | | 100.0 | |
| 10075-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 36 Mbps) | X | 4.99 | 66.96 | 17.98 | 3.82 | 90.0 | ± 9.6 % |
| | | Y | 5.08 | 67.14 | 18.22 | | 90.0 | |
| | | Z | 5.06 | 67.04 | 18.00 | | 90.0 | |
| 10076-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 48 Mbps) | X | 5.01 | 66.78 | 18.11 | 4.15 | 90.0 | ± 9.6 % |
| | | Y | 5.08 | 66.91 | 18.32 | | 90.0 | |
| | | Z | 5.08 | 66.85 | 18.11 | | 90.0 | |
| 10077-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 54 Mbps) | X | 5.04 | 66.85 | 18.20 | 4.30 | 90.0 | ± 9.6 % |
| | | Y | 5.10 | 66.97 | 18.41 | | 90.0 | |
| | | Z | 5.10 | 66.92 | 18.20 | | 90.0 | |



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|-----------|---|---|--------|--------|-------|------|-------|---------|
| 10081-CAB | CDMA2000 (1xRTT, RC3) | X | 0.80 | 65.24 | 12.08 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 0.85 | 65.56 | 12.59 | | 150.0 | |
| | | Z | 0.82 | 65.35 | 12.34 | | 150.0 | |
| 10082-CAB | IS-54 / IS-136 FDD (TDMA/FDM, PI/4-DQPSK, Fullrate) | X | 0.68 | 58.27 | 3.79 | 4.77 | 80.0 | ± 9.6 % |
| | | Y | 0.86 | 60.00 | 4.99 | | 80.0 | |
| | | Z | 0.80 | 58.87 | 4.46 | | 80.0 | |
| 10090-DAC | GPRS-FDD (TDMA, GMSK, TN 0-4) | X | 100.00 | 110.24 | 24.94 | 6.56 | 60.0 | ± 9.6 % |
| | | Y | 100.00 | 111.45 | 25.55 | | 60.0 | |
| | | Z | 61.75 | 105.66 | 24.37 | | 60.0 | |
| 10097-CAB | UMTS-FDD (HSDPA) | X | 1.80 | 67.24 | 15.39 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 1.81 | 67.18 | 15.46 | | 150.0 | |
| | | Z | 1.80 | 67.11 | 15.37 | | 150.0 | |
| 10098-CAB | UMTS-FDD (HSUPA, Subtest 2) | X | 1.76 | 67.18 | 15.35 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 1.78 | 67.13 | 15.43 | | 150.0 | |
| | | Z | 1.76 | 67.04 | 15.33 | | 150.0 | |
| 10099-DAC | EDGE-FDD (TDMA, 8PSK, TN 0-4) | X | 8.51 | 87.74 | 30.17 | 9.56 | 60.0 | ± 9.6 % |
| | | Y | 11.43 | 95.53 | 33.48 | | 60.0 | |
| | | Z | 8.91 | 87.61 | 29.83 | | 60.0 | |
| 10100-CAC | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 3.05 | 69.78 | 16.46 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 3.13 | 70.04 | 16.53 | | 150.0 | |
| | | Z | 3.07 | 69.82 | 16.43 | | 150.0 | |
| 10101-CAC | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM) | X | 3.21 | 67.25 | 15.78 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 3.26 | 67.38 | 15.84 | | 150.0 | |
| | | Z | 3.23 | 67.28 | 15.77 | | 150.0 | |
| 10102-CAC | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 64-QAM) | X | 3.31 | 67.26 | 15.89 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 3.37 | 67.35 | 15.94 | | 150.0 | |
| | | Z | 3.34 | 67.28 | 15.89 | | 150.0 | |
| 10103-CAC | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 5.95 | 73.98 | 19.42 | 3.98 | 65.0 | ± 9.6 % |
| | | Y | 6.46 | 75.28 | 20.05 | | 65.0 | |
| | | Z | 5.88 | 73.30 | 19.04 | | 65.0 | |
| 10104-CAC | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM) | X | 6.15 | 72.74 | 19.68 | 3.98 | 65.0 | ± 9.6 % |
| | | Y | 6.50 | 73.70 | 20.23 | | 65.0 | |
| | | Z | 6.36 | 72.92 | 19.68 | | 65.0 | |
| 10105-CAC | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, 64-QAM) | X | 5.78 | 71.44 | 19.39 | 3.98 | 65.0 | ± 9.6 % |
| | | Y | 6.20 | 72.69 | 20.09 | | 65.0 | |
| | | Z | 6.26 | 72.53 | 19.82 | | 65.0 | |
| 10108-CAD | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 2.66 | 69.02 | 16.27 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.74 | 69.24 | 16.34 | | 150.0 | |
| | | Z | 2.69 | 69.04 | 16.24 | | 150.0 | |
| 10109-CAD | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 16-QAM) | X | 2.86 | 67.09 | 15.67 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.92 | 67.19 | 15.74 | | 150.0 | |
| | | Z | 2.89 | 67.10 | 15.67 | | 150.0 | |
| 10110-CAD | LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK) | X | 2.15 | 68.08 | 15.82 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.23 | 68.29 | 15.94 | | 150.0 | |
| | | Z | 2.18 | 68.07 | 15.80 | | 150.0 | |
| 10111-CAD | LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 16-QAM) | X | 2.58 | 67.97 | 15.95 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.63 | 67.86 | 15.99 | | 150.0 | |
| | | Z | 2.60 | 67.91 | 15.97 | | 150.0 | |



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|-----------|--|---|------|-------|-------|------|-------|---------|
| 10112-CAD | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 64-QAM) | X | 2.99 | 67.13 | 15.75 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 3.05 | 67.18 | 15.80 | | 150.0 | |
| | | Z | 3.01 | 67.13 | 15.74 | | 150.0 | |
| 10113-CAD | LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 64-QAM) | X | 2.73 | 68.15 | 16.11 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.78 | 68.00 | 16.13 | | 150.0 | |
| | | Z | 2.76 | 68.09 | 16.12 | | 150.0 | |
| 10114-CAB | IEEE 802.11n (HT Greenfield, 13.5 Mbps, BPSK) | X | 5.12 | 67.14 | 16.40 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 5.16 | 67.11 | 16.38 | | 150.0 | |
| | | Z | 5.14 | 67.13 | 16.37 | | 150.0 | |
| 10115-CAB | IEEE 802.11n (HT Greenfield, 81 Mbps, 16-QAM) | X | 5.39 | 67.23 | 16.45 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 5.47 | 67.32 | 16.49 | | 150.0 | |
| | | Z | 5.43 | 67.27 | 16.45 | | 150.0 | |
| 10116-CAB | IEEE 802.11n (HT Greenfield, 135 Mbps, 64-QAM) | X | 5.20 | 67.31 | 16.41 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 5.26 | 67.33 | 16.42 | | 150.0 | |
| | | Z | 5.23 | 67.32 | 16.39 | | 150.0 | |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 5.08 | 66.99 | 16.34 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 5.13 | 67.01 | 16.35 | | 150.0 | |
| | | Z | 5.10 | 67.00 | 16.32 | | 150.0 | |
| 10118-CAB | IEEE 802.11n (HT Mixed, 81 Mbps, 16-QAM) | X | 5.47 | 67.43 | 16.56 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 5.55 | 67.51 | 16.60 | | 150.0 | |
| | | Z | 5.51 | 67.48 | 16.56 | | 150.0 | |
| 10119-CAB | IEEE 802.11n (HT Mixed, 135 Mbps, 64-QAM) | X | 5.19 | 67.27 | 16.40 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 5.23 | 67.26 | 16.40 | | 150.0 | |
| | | Z | 5.21 | 67.26 | 16.38 | | 150.0 | |
| 10140-CAC | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, 16-QAM) | X | 3.35 | 67.26 | 15.81 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 3.41 | 67.36 | 15.86 | | 150.0 | |
| | | Z | 3.37 | 67.28 | 15.80 | | 150.0 | |
| 10141-CAC | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, 64-QAM) | X | 3.47 | 67.39 | 16.00 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 3.53 | 67.45 | 16.03 | | 150.0 | |
| | | Z | 3.50 | 67.41 | 15.99 | | 150.0 | |
| 10142-CAD | LTE-FDD (SC-FDMA, 100% RB, 3 MHz, QPSK) | X | 1.92 | 68.04 | 15.43 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.00 | 68.21 | 15.62 | | 150.0 | |
| | | Z | 1.95 | 68.01 | 15.47 | | 150.0 | |
| 10143-CAD | LTE-FDD (SC-FDMA, 100% RB, 3 MHz, 16-QAM) | X | 2.43 | 68.67 | 15.60 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.48 | 68.53 | 15.74 | | 150.0 | |
| | | Z | 2.46 | 68.63 | 15.70 | | 150.0 | |
| 10144-CAD | LTE-FDD (SC-FDMA, 100% RB, 3 MHz, 64-QAM) | X | 2.19 | 66.27 | 13.92 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.28 | 66.45 | 14.25 | | 150.0 | |
| | | Z | 2.23 | 66.33 | 14.07 | | 150.0 | |
| 10145-CAD | LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, QPSK) | X | 1.16 | 64.50 | 11.31 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 1.29 | 65.42 | 12.29 | | 150.0 | |
| | | Z | 1.24 | 65.05 | 11.89 | | 150.0 | |
| 10146-CAD | LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, 16-QAM) | X | 1.75 | 64.91 | 10.68 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.10 | 66.86 | 12.19 | | 150.0 | |
| | | Z | 1.85 | 65.40 | 11.22 | | 150.0 | |
| 10147-CAD | LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, 64-QAM) | X | 1.99 | 66.41 | 11.55 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.48 | 68.95 | 13.31 | | 150.0 | |
| | | Z | 2.12 | 67.01 | 12.15 | | 150.0 | |



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| 10149-CAC | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, 16-QAM) | X | 2.87 | 67.16 | 15.72 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.93 | 67.25 | 15.78 | | 150.0 | |
| | | Z | 2.90 | 67.17 | 15.71 | | 150.0 | |
| 10150-CAC | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, 64-QAM) | X | 3.00 | 67.19 | 15.79 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 3.05 | 67.23 | 15.84 | | 150.0 | |
| | | Z | 3.02 | 67.19 | 15.79 | | 150.0 | |
| 10151-CAC | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.19 | 76.09 | 20.32 | 3.98 | 65.0 | ± 9.6 % |
| | | Y | 6.72 | 77.39 | 20.98 | | 65.0 | |
| | | Z | 6.36 | 75.98 | 20.19 | | 65.0 | |
| 10152-CAC | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, 16-QAM) | X | 5.64 | 72.49 | 19.24 | 3.98 | 65.0 | ± 9.6 % |
| | | Y | 6.02 | 73.58 | 19.91 | | 65.0 | |
| | | Z | 5.85 | 72.65 | 19.26 | | 65.0 | |
| 10153-CAC | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, 64-QAM) | X | 6.03 | 73.53 | 20.06 | 3.98 | 65.0 | ± 9.6 % |
| | | Y | 6.38 | 74.47 | 20.65 | | 65.0 | |
| | | Z | 6.24 | 73.66 | 20.07 | | 65.0 | |
| 10154-CAD | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 2.20 | 68.51 | 16.09 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.28 | 68.70 | 16.20 | | 150.0 | |
| | | Z | 2.23 | 68.51 | 16.09 | | 150.0 | |
| 10155-CAD | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, 16-QAM) | X | 2.58 | 67.98 | 15.97 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.63 | 67.87 | 16.01 | | 150.0 | |
| | | Z | 2.61 | 67.92 | 15.98 | | 150.0 | |
| 10156-CAD | LTE-FDD (SC-FDMA, 50% RB, 5 MHz, QPSK) | X | 1.76 | 68.06 | 15.17 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 1.85 | 68.29 | 15.45 | | 150.0 | |
| | | Z | 1.80 | 68.08 | 15.26 | | 150.0 | |
| 10157-CAD | LTE-FDD (SC-FDMA, 50% RB, 5 MHz, 16-QAM) | X | 2.02 | 66.77 | 13.91 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.12 | 66.99 | 14.30 | | 150.0 | |
| | | Z | 2.07 | 66.86 | 14.11 | | 150.0 | |
| 10158-CAD | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, 64-QAM) | X | 2.74 | 68.22 | 16.16 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.79 | 68.06 | 16.17 | | 150.0 | |
| | | Z | 2.77 | 68.16 | 16.17 | | 150.0 | |
| 10159-CAD | LTE-FDD (SC-FDMA, 50% RB, 5 MHz, 64-QAM) | X | 2.12 | 67.25 | 14.20 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.23 | 67.45 | 14.59 | | 150.0 | |
| | | Z | 2.18 | 67.37 | 14.42 | | 150.0 | |
| 10160-CAC | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 2.69 | 68.25 | 16.09 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.75 | 68.31 | 16.13 | | 150.0 | |
| | | Z | 2.71 | 68.19 | 16.05 | | 150.0 | |
| 10161-CAC | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, 16-QAM) | X | 2.89 | 67.14 | 15.71 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 2.95 | 67.16 | 15.77 | | 150.0 | |
| | | Z | 2.92 | 67.13 | 15.72 | | 150.0 | |
| 10162-CAC | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, 64-QAM) | X | 3.00 | 67.31 | 15.83 | 0.00 | 150.0 | ± 9.6 % |
| | | Y | 3.06 | 67.29 | 15.87 | | 150.0 | |
| | | Z | 3.03 | 67.28 | 15.83 | | 150.0 | |
| 10166-CAD | LTE-FDD (SC-FDMA, 50% RB, 1.4 MHz, QPSK) | X | 3.52 | 69.26 | 18.89 | 3.01 | 150.0 | ± 9.6 % |
| | | Y | 3.63 | 69.41 | 18.97 | | 150.0 | |
| | | Z | 3.54 | 68.96 | 18.65 | | 150.0 | |
| 10167-CAD | LTE-FDD (SC-FDMA, 50% RB, 1.4 MHz, 16-QAM) | X | 4.34 | 72.30 | 19.40 | 3.01 | 150.0 | ± 9.6 % |
| | | Y | 4.53 | 72.61 | 19.56 | | 150.0 | |
| | | Z | 4.33 | 71.71 | 19.05 | | 150.0 | |