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Applicant Name: **Flextronics Canada Design Services Inc.**

Applicant Address: **1280 Teron Rd
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Project Number: **5838**

Test/Analysis Date: **June 7 – 16, 2017**

FCC ID: **QQD-EC3331**

IC: **5248S-EC3331**

DUT Type	Edge computing gateway
Antenna Type	Internal
Project Name	EC3331
Version Number	1
Received Status	Functional final design
DUT Serial Number	FZAUS171100020
Experimental/Compliance	Compliance
Tx Frequency	GSM850, EGSM 900, DCS 1800 and PCS 1900 (GPRS) W-CDMA Band 1, 2, 5, and 8 WiFi 802.11b/g/n
Max Tx Power Measured	GSM 850 = **32.1 dBm** EGSM 900 = **32.2 dBm** DCS1800 = **30.3 dBm** PCS1900 = **30.3 dBm** W-CDMA Band 1 = **21.5 dBm** W-CDMA Band 2 = **21.5 dBm** W-CDMA Band 5 = **22.6 dBm** W-CDMA Band 8 = **22.8 dBm** WIFI 802.11b = **16.95 dBm (Avg)** WIFI 802.11g = **11.45 dBm (Avg)** WIFI 802.11n = **12.55 dBm (Avg)**
Maximum SAR Measured	1-g SAR: **1.318 W/kg @ 5mm separation** 10-g SAR: **0.115 W/kg @ 5mm separation**
Simultaneous Transmission	W-CDMA 1 + WiFi 802.11b Rate 5.5 Channel 6 1-g SAR: **1.39 W/kg @ 5mm separation**

Statement of compliance

The maximum measured levels of Specific Absorption Rate (SAR) for the Flex Austonio are as follows:

W-CDMA	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg@ 5mm Separation	Uncertainty (K=2), %
Band 1	**1.318**	**0.115**	**18.7**
Band 2	1.168	0.098	18.9
Band 5	0.466	0.244	19.5
Band 8	0.886	0.551	19.7

GSM	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg@ 5mm Separation	Uncertainty (K=2), %
GSM850	0.895	0.578	19.0
EGSM	**0.903**	**0.583**	**18.6**
DCS	0.515	0.282	20.1
PCS	0.904	0.499	20.2

WiFi	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg@ 5mm Separation	Uncertainty (K=2), %
802.11b	**0.223**	**0.132**	**19.1**
802.11g	0.157	0.100	19.7
802.11n	0.159	0.099	20.7

The maximum evaluated levels of combined SAR for simultaneous transmission of W-CDMA and WiFi are as follows:

Simultaneous Signals		1g SAR, W/kg	St Deviation for 1-g SAR approximation formula
WiFi 802.11b Rate 5.5 Channel 6	W-CDMA 1	1.39	1.04 %
WiFi 802.11b Rate 5.5 Channel 6	W-CDMA 2	1.24	1.05 %
WiFi 802.11g Rate 6 Channel 1	W-CDMA 1	1.34	0.55 %
WiFi 802.11g Rate 6 Channel 1	W-CDMA 2	1.19	0.56 %

Based on the attestation received from Flex (Appendix B) regarding the additional transmit modes which can be used simultaneously and our analysis of Low Power Exclusion (less than 10mW combined with antenna gain) per **OET Laboratory Division FCC KDB 447498 Mobile and Portable Device RF Exposure Equipment Authorization Procedures** no additional SAR analysis was made for the Bluetooth, Z-Wave transceivers. For NFC analysis due to the frequency exclusion for **IEC 62209-2:2010 Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)** no additional SAR analysis was made**.**

We the undersigned of APREL, located at Suite 102, 303 Terry Fox Dr., Ottawa, Ontario, Canada, K2K 3J1, on the date indicated attest that the Device Under Test as detailed within this test report has

been tested and found to be compliant with the Uncontrolled Environment RF exposure rules and regulations as defined by the methodologies, procedures, and standards as described in this document.
Signed this day June 15th 2017.

NOTE: Below is an electronic copy. Each report is signed upon release

Maryna Nestrovna, Test Engineer

Art Brennan, Document Control

Released by:
Stuart Nicol, Director Product Development

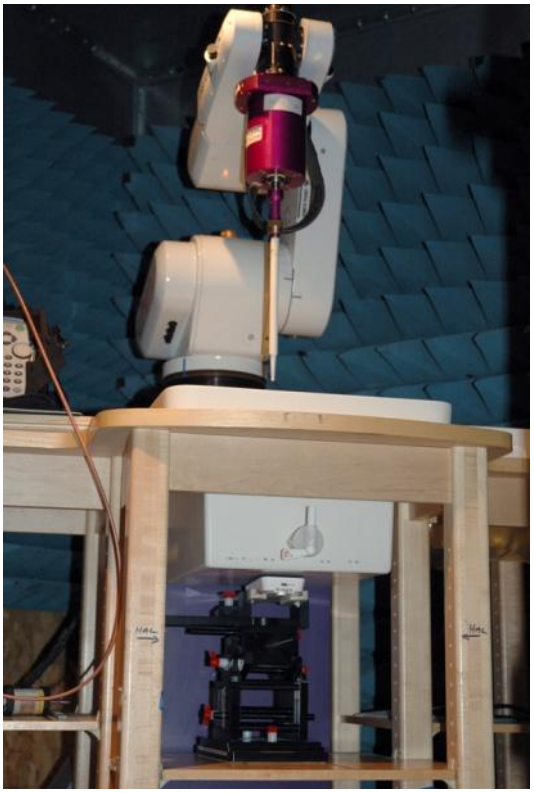
Contents

1 Introduction

Tests were conducted at APREL within the SAR facility to establish the conservative exposure value associated with the Device Under Test (DUT) as detailed within this test report. Assessments were made in line with the guidelines contained in the reference documents. The method used for assessment was the ALSAS-10U (APREL SAR Assessment System-10 Universal). All practices along with standards and scientific methodologies which have been utilized during the assessment of the DUT) are detailed within this test report.

APREL employees currently hold senior and executive positions in multiple international standards organizations, including IEC, IEEE, among others, and work closely with several national regulators, including the FCC and ISEDC. APREL currently hold the chair for the Canadian National committee to IEC to which we have a liaison with EUROPEAN, and informal links to other national and international standards organizations. APREL are certified to ISO/IEC-17025 by ANSI-ASQ National Accreditation Board to conduct SAR measurements (Appendix C).

1.1 Device Description



The device tested is a gateway device which utilises WCDMA, GPRS, WiFi, GNSS (GPS, Glonass), NFC, Bluetooth, and Z-Wave. The device is designed to operate placed in a cradle with an option to be occasionally worn in close proximity to a body (e.g. in a pocket). All tests conducted used a body type Flat Phantom with body tissue. The device was assessed using standard WCDMA, WiFi, and GPRS functions at a maximum rated transmit power per the details in this report.

NOTE:

Per the guidance of the manufacturer the additional wireless transceivers NFC, Bluetooth, and Z-Wave were not tested due to complying with low power exclusions.

The maximum transmit power level in WCDMA bands 1 and 2 was reduced by 1.5 dB using a software application during SAR testing. This 1.5 dB power reduction provided an optimal balance between SAR levels and over-the-air performance. All production devices will have the 1.5 dB maximum power level reduction in WCDMA bands 1 and 2 applied permanently in the radio code. Production devices will match the behavior of the SAR measured devices.

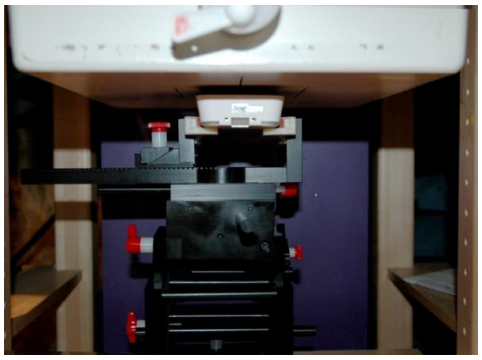
It was found that the conservative SAR was measured for W-CDMA signal Band 1 low channel (#10562, frequency 2010 MHz).

The device was assessed for the combined SAR (Alternative 3 method [7], [8], [10]). For this evaluation worst 1-g SAR cases of W-CDMA Bands 1 and 2 were combined with scans with the highest measured 1-g SAR of WiFi 802.11b/g/n. All possible combinations showed results lower than limit of 1.6 W/kg for 1-g spatially averaged SAR.

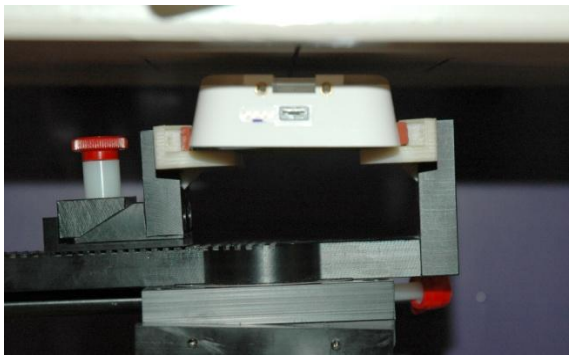
For 10g average SAR the maximum values measured was significantly less than 1mW k/g.

Device Positioning under Phantom

1.1



Front



Back

Side

Bottom

1.2 Antenna Locations

Antenna Locations

Device dimensions

Length	135 mm
Width	65 mm
Depth	25 mm

2 Applicable Reference Documents

1. ANSI/IEEE C95.1-1999, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

2. ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.

3. OET Bulletin 65 (Edition 97-01) Supplement C (Edition 01-01), “Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields”.

4. OET Laboratory Division FCC SAR Evaluation Considerations for Laptop Computers with Antennas Built –in on Display Screens

5. OET Laboratory Division FCC (May 2007 Revised) SAR Measurement Procedures for 802.11abg Transmitters

6. OET Laboratory Division FCC (October 2006) SAR Measurement Procedures for 3-6GHz

7. IEEE Standard 1528:2013 IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques

8. ICNIRP guidelines “guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 ghz)”

9. IEC 62209-1:2006 Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models. instrumentation, and procedures - Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices

10. IEC 62209-2:2010 Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)

11. OET Laboratory Division FCC KDB 447498 Mobile and Portable Device RF Exposure Equipment Authorization Procedures

12. RSS 102 Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

13. OET Laboratory Division FCC KDB 865664 SAR Measurement 100 MHz to 6 GHz

3 ALSAS-10U System Description

APREL ALSAS-10-U (APREL SAR Assessment System) is fully optimized for the dosimetric evaluation of a broad range of wireless transceivers and antennas. It is an easy-to-use development and compliance tool, which provides excellent application flexibility. Developed in line with the latest methodologies it is fully compliant with the technical and scientific requirements of IEEE 1528, IEC 62212/62209, EUROPEAN, ARIB, ACA, and the Federal Communications Commission. The system comprises of a six axes articulated robot which utilizes a dedicated controller.

ALSAS-10U has been developed with a strong engineering focus, and with custom modular software/hardware for the broadest range of applications, including dosimetry research and measurements in various Phantoms – SAM Phantom, UniPhantom™ Universal Phantom, Universal Flat Phantom and others.

Free space E-Field measurements of mobile devices and base station antennas can also be executed using ALSAS. With the current ALSAS configuration, several phantoms and setups can be arranged around the system – and since the phantoms are designed to be light and easy to move for interchanging between test frequencies.

ALSAS-10U has been developed using the latest methodologies and FDTD modeling to provide a platform which is repeatable with minimum uncertainty.

The ongoing commitment from APREL to the field of Dosimetric research and development will ensure that the ALSAS-10-U measurement system can easily be upgraded to accommodate changes to wireless technologies, and scientific methodologies.

3.1 Applications

Predefined measurement procedures compliant with the guidelines of EUROPEAN, IEEE, IEC, FCC, etc are utilized during the assessment for the device. Automatic detection for all SAR maxima are embedded within the core architecture for the system, ensuring that peak locations used for centering the zoom scan are within a 1mm resolution and a 0.05mm repeatable position. A little less than 20 min per device position measurement completion time, (depending of DUT size) ensures minimum power drift during the assessment. No user interaction is required during the measurement processes: area scan, evaluation of cube maximal search, fine cube measurements and device power drift measurement. System operation range currently available up-to 6 GHz in simulated tissue.

ALSAS-10U can be used for all analog and digital devices, including wideband, spread spectrum and pulsed systems, etc.: handsets, handhelds, wireless data, electronic article surveillance, accessories, wireless access points, WLAN, cordless, radio, etc.

3.2 Visualization and reporting

2/3D isoline distribution, scatter graphics, polar graphics, and vector reproduction. Device representation and phantom visualization in 2/3D graphics with measurement data overlaid (in color plot format). Freely configurable output graphic formats with automatic title, data and legend generation which includes all relevant information relating to the measurement process. Uncertainty analysis and budget calculated and reported drawing on active device drift assessment, and tissue simulation values.

3.3 Field scans

ALSAS-10U can provide multiple scan types including Measurements along lines (X, Y, Z), multiple planes, curved surfaces (normalize probe to surface), volumes in free space or restricted volumes (phantoms). Cube measurements with surface extrapolation and spatial SAR evaluation for 1g and/or 10g. Time measurements (source power drift). Probe rotation measurements (isotropy) and many others in line with the requirements of any given standard or procedure.

3.3.1 Area Scans

Area scans are defined prior to the measurement process being executed with a user defined variable spacing between each measurement point (integral) allowing low uncertainty measurements to be conducted. Scans defined for FCC applications utilize a $10mm^2$ step integral, with 1mm interpolation used to locate the peak SAR area used for zoom scan assessments.

A maximum area scan size is set at 280mm x 200mm which can be changed to a smaller size dependent on the filed distribution of the device under test. The area scan size is documented within the SAR report which is delivered by the SAR system software.

Where the system identifies multiple SAR peaks (which are within 2dB of each peak value) the system will provide the user with the option of assessing each peak location individually for zoom scan averaging.

3.3.2 Zoom Scan (Cube Scan Averaging)

The averaging zoom scan volume utilized in the ALSAS-10U software is in the shape of a cube and the side dimension of a 1 g or 10 g mass is dependent on the density of the liquid representing the simulated tissue. A density of 1 000 kg/m^3 is used to represent the head and body tissue density and not the phantom liquid density, in order to be consistent with the definition of the liquid dielectric properties, i.e. the side length of the 1 g cube is 10mm, with the side length of the 10 g cube 21,5mm.

When the cube intersects with the surface of the phantom, it is oriented so that 3 vertices touch the surface of the shell or the centre of a face is tangent to the surface. The face of the cube closest to the surface is modified in order to conform to the tangent surface. The centre of the cube and the tangential angle associated defines each face of the cube so that all transitional points follow this tangential angle.

The zoom scan integer steps can be user defined so as to reduce uncertainty, but normal practice for typical test applications (including FCC) utilize a physical step of 5x5x9 (8mmx8mmx4mm Fx <3GHz) and 9x9x17 (4mmx4mmx2mm Fx>3GHz) providing a volume of 32mm in the X & Y axis, and 32mm in the Z axis. All points remain tangential to the surface by utilizing the normalize (probe tilt) feature so as to reduce measurement uncertainty.

3.4 Operator settings

Multiple access levels (password protected) for parametric modifications/test scenarios in line with selected standards, including the FCC. Any number of predefined settings (probes, phantoms, liquids, devices, measurement procedures, etc.) can be stored for future use and repeatable assessments.

3.5 ALSAS-10U Interpolation and Extrapolation Uncertainty

The overall uncertainty for the methodology and algorithms that are used during the SAR calculation was evaluated using the data from IEEE 1528 based on the example f3 algorithm:

$$f_3(x,y,z) = A\,\frac{a^2}{\frac{a^2}{4} + x'^2 + y'^2}\cdot\left(e^{-\frac{2z}{a}} + \frac{a^2}{2(a+2z)^2}\right)$$

4 ALSAS-10U Hardware

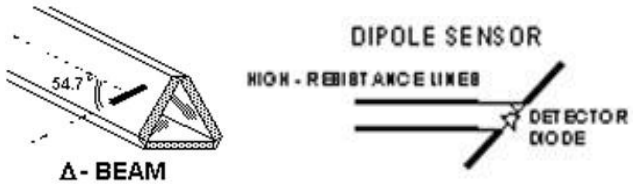
The ALSAS-10U comprises of hardware designed exclusively by APREL based on methodologies presented in IEEE 1528, IEC 62212, EUROPEAN and FCC supplement C OET bulletin 65.

4.1 Isotropic E-Field Probe

The isotropic E-Field probe used by APREL, has been fully calibrated and assessed for isotropicity, and boundary effect within a controlled environment. Depending on the frequency for which the probe is calibrated the method utilized for calibration will change. APREL utilize a number of methods for calibrating probes, and these are outlined in the table below.

Calibration Frequency (MHz)	Air Calibration	Tissue Calibration
300	TEM Cell	Temperature
450	TEM Cell	Temperature
835	TEM Cell	Temperature
900	TEM Cell	Temperature
1800	TEM Cell	Temperature
1900	TEM Cell	Temperature
2450	Waveguide	Waveguide
5200	Waveguide	Waveguide
5600	Waveguide	Waveguide
5800	Waveguide	Waveguide

The APREL E-Field probe utilizes a triangular sensor arrangement as detailed in the diagram below.



SAR is assessed with a calibrated probe which moves at a default height of 1.4mm from the centre of the diode, which is mounted to the sensor, to the phantom surface (in the Z Axis). The 1.4mm offset height has been selected so as to minimize any resultant boundary effect due to the probe being in close proximity to the phantom surface.

The following algorithm is an example of the function used by the system for linearization of the output from the probe when measuring complex modulation schemes.

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

4.2 Isotropic E-Field Probe Specification

Calibration in Air	Frequency Dependent Below 2GHz Calibration in air performed in a TEM Cell Above 2GHz Calibration in air performed in waveguide
Sensitivity	0.60 $\mu V/(V/m)^2$ to 1.25 $\mu V/(V/m)^2$
Dynamic Range	0.01 W/kg to 100 W/kg
Isotropic Response	Better than 0.2dB in air Better than 0.05dB in tissue
Diode Compression Point (DCP)	Calibrated for Specific Frequency typically 95mV +/- 10%
Probe Tip Radius	<2.9mm
Sensor Offset	1.06 (+/-0.02mm)
Probe Length	290mm
Video Bandwidth	@ 500 Hz: 1 dB @ 1.02 KHz: 3 dB
Boundary Effect	Less than 2% for distances greater than 1.4mm
Spatial Resolution	Better than 1mm
Probe Diameter	Less than 2.8mm

4.3 Boundary Detection Unit and Probe Mounting Device

ALSAS-10U incorporates a boundary detection unit with a sensitivity of 0.05mm for detecting all types of surfaces. The robust design allows for detection during probe tilt (probe normalize) exercises, and utilizes a second stage emergency stop. The signal electronics are fed directly into the robot controller for high accuracy surface detection in lateral and axial detection modes (X, Y, & Z).

The probe is mounted directly onto the Boundary Detection unit for accurate tooling and displacement calculations controlled by the robot kinematics. The probe is connect to an isolated probe interconnect where the output stage of the probe is fed directly into the amplifier stage of the Daq-Paq.

4.4 Daq-Paq (Analog to Digital Electronics)

ALSAS-10U incorporates a fully calibrated Daq-Paq (analog to digital conversion system) which has a 4 channel input stage, sent into an amplifier module. The input signal is amplified accordingly so as to offer a dynamic range from 5µV to 800mV. Integration of the fields measured is carried out at board level utilizing a Co-Processor which then sends the measured fields down into the main computational module in digitized form via an RS232 communications port. Probe linearization and duty cycle compensation is carried out within the main Daq-Paq module.

ADC	16 Bit
Amplifier Range	30 µV to +200 mV (16 bit resolution: 4µV, 400mV)
Field Integration	Local Co-Processor utilizing proprietary integration algorithms
Number of Input Channels	4 in total 3 dedicated and 1 spare
Communication	Packet data via RS232

4.5 Axis Articulated Robot

ALSAS-10U utilizes a six axis articulated robot, which is controlled using a Pentium based real-time movement controller. The movement kinematics engine utilizes proprietary (Thermo CRS) interpolation and extrapolation algorithms, which allow full freedom of movement for each of the six joints within the working envelope. Utilization of joint 6 allows for full probe rotation with a tolerance better than 0.05mm around the central axis.

Robot/Controller Manufacturer	Thermo CRS
Number of Axis	Six independently controlled axis
Positioning Repeatability	0.05mm
Controller Type	Single phase Pentium based C500C
Robot Reach	710mm
Communication	RS232 and LAN compatible

4.6 ALSAS Universal Workstation

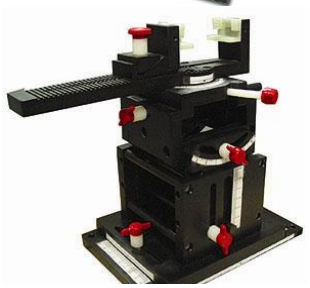
ALSAS Universal workstation was developed with a strong engineering focus taking into consideration flexibility and engineering needs, and the necessity to have integrated system which will allow for repeatability and fast adaptability. ALSAS workstation technology is stable and robust in structure, but at the same time flexible so that users can do calibration, testing and measurements using different types of phantoms with one set up, which significantly speeds up the measurement process.

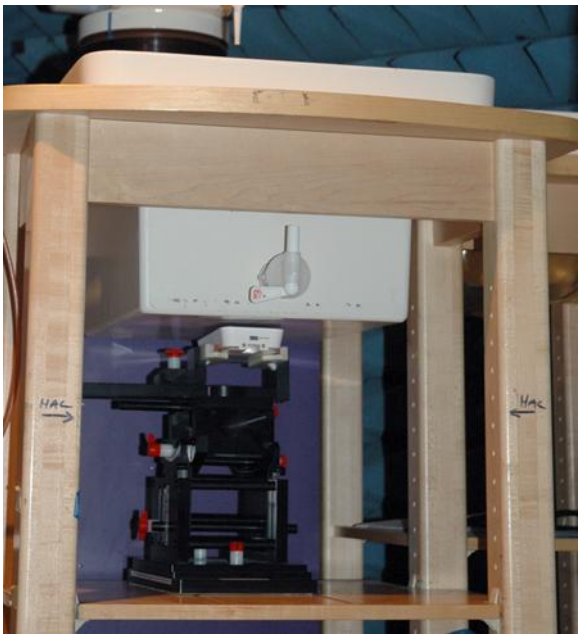
The workstation incorporates a modular structure which can be easily adapted to specific engineering requirements and needs. Phantoms which are self contained modular units are easily located, removable and swappable. Three fully configurable shelves allow for setting up of a test device in a way which can either utilize the APREL device positioner, or custom designed units. When using the modular shelf for positioning of a device, additional loading characteristics have been avoided.

The workstation has been constructed entirely out of composite wood and Canadian maple, with all metallic fasteners kept at a compliant distance from the Device under test.

4.7 Universal Device Positioner

The APREL universal device positioner has been developed so as to allow complete freedom of movement of the DUT. Developed to hold a DUT in a free-space scenario any additional loading attributable to the material used in the construction of the positioner has been eliminated. Repeatability has been enhanced through the linear scales which form the design used to indicate positioning for any given test scenario in all major axes. A 15° tilt indicator has been included for the of aid cheek to tilt movements for head SAR analysis. Overall uncertainty for measurements have been reduced due to the design of the Universal device positioner, which allows positioning of a device in as near to a free-space scenario as possible, and by providing the means for complete repeatability.





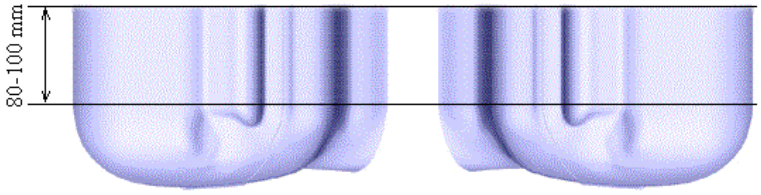
Length	201mm
Width	140mm
Height	222mm
Weight	1.95kg
Number of Axis	6 axis freedom of movement
Translation Along MB Line	+/- 76.2mm
Translation Along NF Line	+/- 38.1mm
Translation Along Z Axis	+/- 25.4mm (expandable to 500mm)
Rotation Around MB Line (yaw)	+/- 10°
Rotation Around NF Line (pitch)	+/- 30°
Rotation Around Z Axis (roll)	360° full circle
Minimum Grip Range	0mm
Maximum Grip	152mm
Maximum Distance from Device to Positioner Material	40mm
Tilt Movement	Full movement with predefined 15° guide

4.8 Phantom Types

The ALSAS-10U has been designed so as to allow the integration of multiple phantom types. This includes but is not limited to the APREL SAM Phantoms fully compliant with IEEE 1528, Universal Phantom, and Universal Flat.

4.8.1 APREL SAM Phantoms

The APREL SAM phantoms have been designed so as to aid repeatability and positioning for any DUT. Developed using the IEEE SAM CAD file they are fully compliant with the requirements for both IEEE 1528 and FCC Supplement C. Both the left and right SAM phantoms are interchangeable, transparent and include the IEEE 1528 grid with visible NF and MB lines.



Compliant Standards	IEEE-1528, IEC 62212, EUROPEAN, and others
Manufacturing Process	Injection molded
Material	Composite urethane
Manufacturing Tolerance	+/- 0.2mm
Frame Material	Corian
Tissue Simulation Volume	7 ltr with 15cm tissue
Thickness	2mm nominally 6mm at NF/MB intersection
Loss Tangent	<0.05
Relative Permittivity	<5
Resistant to Solvents	Resistant to all solvents detailed in IEEE 1528
Load Deflection	<1mm with sugar water compositions

4.8.2 APREL Uni-Flat Phantom (body)

The APREL Flat Phantom has been developed as an engineering tool for SAR compliance and development testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. The enhanced design allows repeatable measurements for a wide range of devices, including handsets, PDA units, laptops, tablets, computers, and validation dipoles.

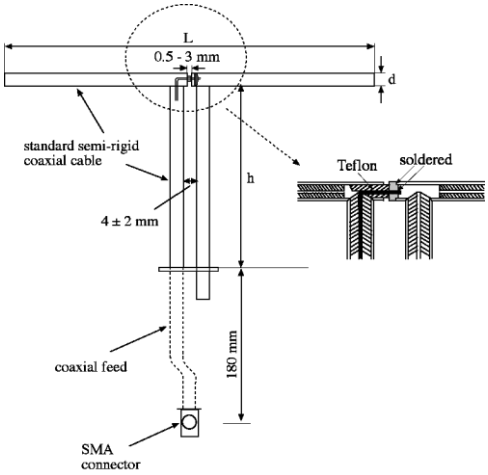
The APREL Flat Phantom is IEEE 1528; IEC 62209-1/IEC 62209-2 (Elliptic flat phantoms); FCC OET Bulletin 65 /Ed. 97-01 (custom flat phantoms) compliant and compatible with tissue-equivalent liquid chemicals.

Compliant Standards	IEEE-1528, IEC 62209, EUROPEAN, and others
Manufacturing Process	Compression molded
Material	S-Glass and Vinyl Ester Resin
Phantom Shell Shape Tolerance	Less than ± 0.2 mm
Operating Frequency Range	30 MHz – 6 GHz
Tissue Simulation Liquid Volume	12.8 liter with a liquid depth of 150 mm
Shell Thickness	2mm ± 0.2mm
Loss Tangent	< 0.05
Relative Permittivity	< 4
Resistant to Solvents	Resistant to all solvents specified in IEEE 1528, IEC 62209 (Part 1 and 2)
Load Deflection	<1.8 mm
Dimensions without frame	320 mm x 250 mm x 225 mm

4.9 Validation Dipoles

APREL utilize dipoles based on the IEEE-1528 standard, and have ensured that they comply with mechanical and electrical specifications in line with the requirements of both IEEE and FCC Supplement C. the table below provides details for the mechanical and electrical specifications for the dipoles used by APREL.

Body validation target numbers have been derived using XFDTD numerical software, and validated experimentally.



APREL have developed high frequency dipoles based on current scientific research carried both experimentally and numerically here at the APREL site. Mechanical and electrical parameters for the dipoles have been established using experimental and numerical techniques, and target SAR values have been established following IEC methodologies. The results of the experimental and numerical research have been published and released for peer review.

Frequency (MHz)	*L* (mm)	*h* (mm)	*d* (mm)
300	396.0	250.0	3.6
450	270.0	166.7	3.6
835	161.0	89.8	3.6
900	149.0	83.3	3.6
1450	89.1	51.7	3.6
1800	72.0	41.7	3.6
1900	68.0	39.5	3.6
2100	64.5	37.5	3.6
2450	51.5	30.4	3.6
2600	49.0	30.0	3.6
3000	41.5	25.0	3.6
5200	23.6	21.2	3.6
5800	21.6	20.0	3.6
5190-5900	23.1	20.7	3.6

5 Tissue Simulation Fluid

Tissue simulation fluids in the frequency range of 450MHz to 2450MHz are based on IEEE-1528 and FCC Supplement C guidelines. All fluids meet the dielectric specifications as outlined in the above standards (within allowable tolerances) and are calibrated on a regular basis, to maintain stability. The recipes used along with the dielectric target values are included in the table below.
NOTE. Recipes are based on those presented in IEC-62209 Part 2.

5.1 Tissue Calibration Procedure Using a Coaxial Probe

The VNA (Vector Network Analyzer) is configured and calibrated for the frequency of the simulated tissue which has to be assessed. The Coaxial probe is then calibrated in line with the tissue frequency using an open, short, and De-Ionized water routine. The sample of simulated tissue is placed into a non-metallic container for use during the calibration. The temperature of the simulated tissue sample is measured. The probe head is then completely immersed in the simulated tissue sample (the probe is held in place using a non metallic probe holder). The simulated tissue sample is then measured to assess the permittivity and conductivity.

5.2 Tissue Calibration Results

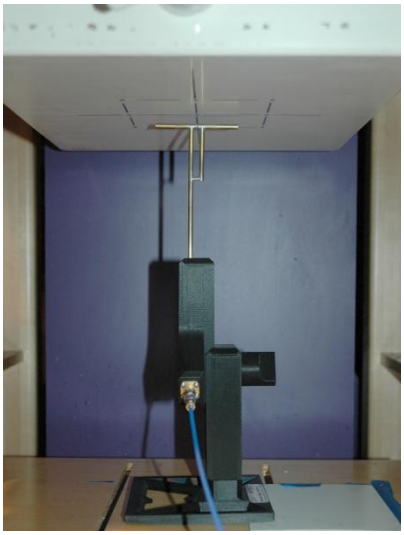
Tissue used during the SAR assessment is calibrated prior to use in the measurement process. APREL use the co-axial probe method for all tissue calibration exercises. Tissue which is being used over a period of 24 hours is re-calibrated to ensure that no change to the dielectric properties will affect the SAR measurement process. The table below provides details of the results from the tissue equivalent dielectric calibration. This project was conducted over a period of 6 days and the tissues were calibrated daily to ensure that they met the values presented below.

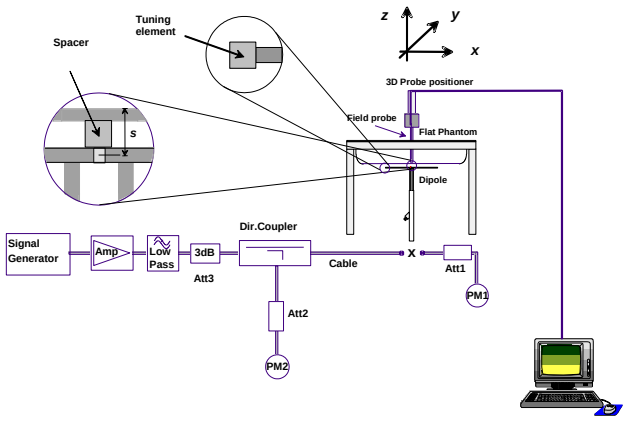
Calibration Date	Frequency MHz	Tissue Type	Epsilon (ε^r)	Sigma (δ)
June 7	850	Body	54.62	1.00
June 7	900	Body	53.7	1.05
June 8	1800	Body	52.95	1.50
June 12	1900	Body	51.12	1.57
June 13	2100	Body	52.78	1.58
June 9	2450	Body	53.59	1.90

Variation of the tissue was maintained to be less than 5%.

6 System Validation

ALSAS-10U is fully validated prior to the SAR assessment of the DUT following methodologies presented in IEEE-1528 section 8. The system is validated using tissue which has been calibrated within a 24 hour period. When the measurement process exceeds a 24 hour period a secondary system validation is executed and the results presented within this test report. The graphic plots resulting from the system validation are included in Appendix A SAR plots.



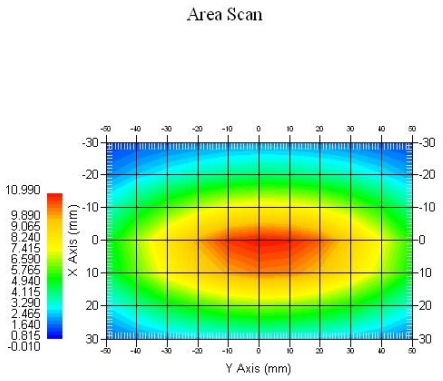


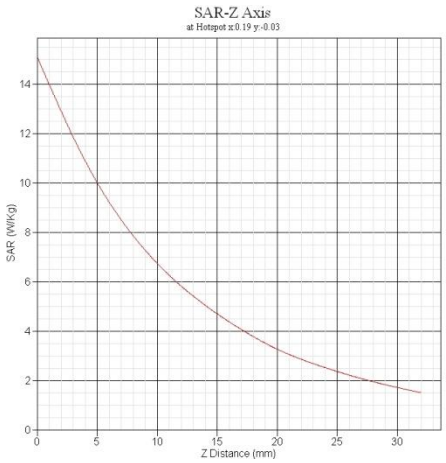
Date	Validation Frequency (MHZ)	Dipole Separation Distance mm	Power W	Dipole	SAR 1g, W/kg	Target 1g, W/kg
June 7	835	15	1	850	9.95	9.56
June 7	900	15	1	900	11.50	10.9
June 9	1800	10	1	1800	38.19	38.4
June 12	1900	10	1	1900	41.62	39.7
June 13	2100	10	1	2100	41.58	43.6
June 8	2450	10	1	2450	52.34	52.4

All validation measurements are conducted in line with IEC-62209 and relevant KDBs as issued by the FCC.

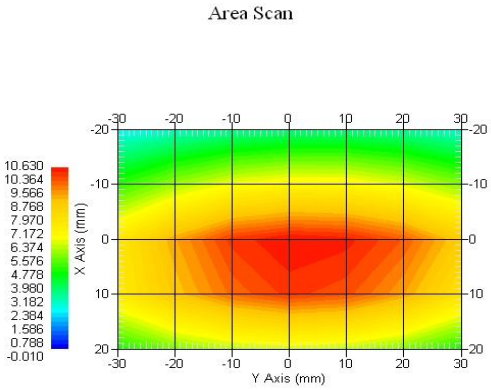
6.1 Validation Plots

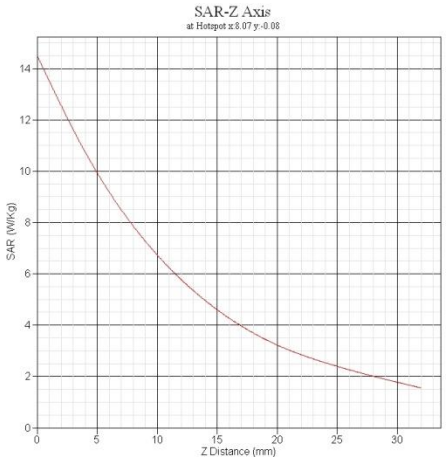
850MHz System Check



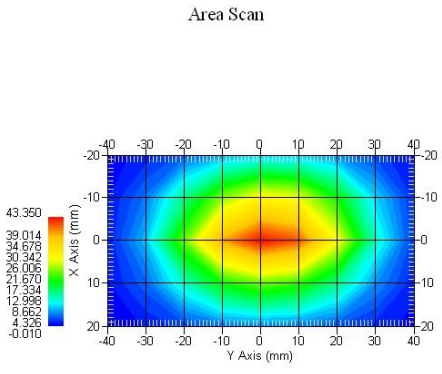


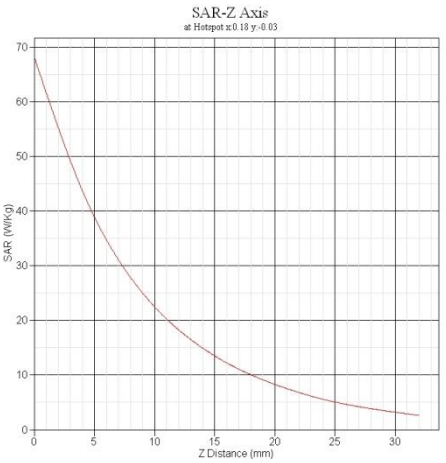
900MHz System Check



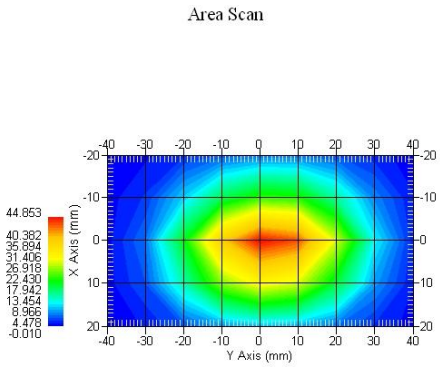


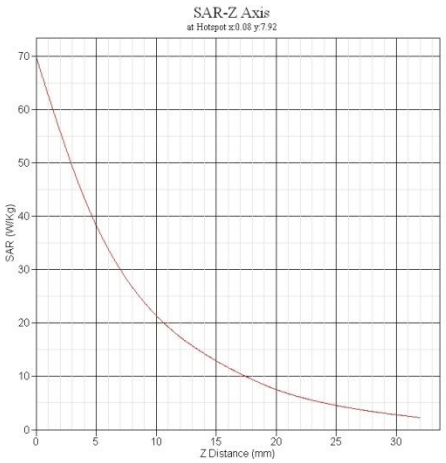
1800 MHz Validation



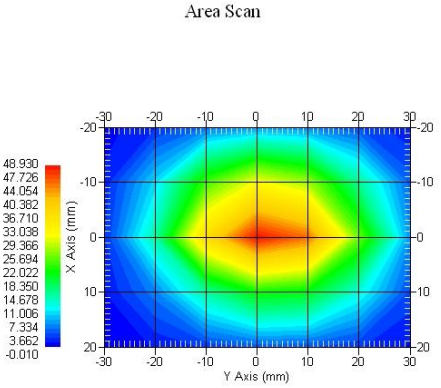


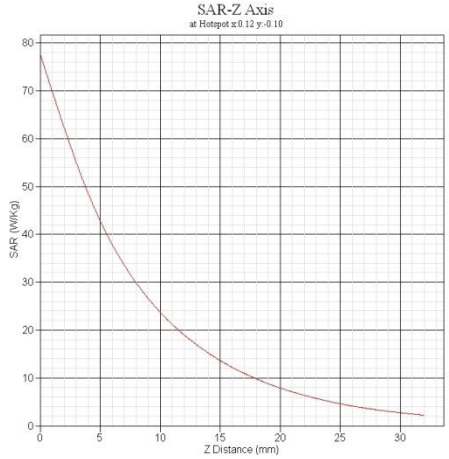
1900 MHz System Check



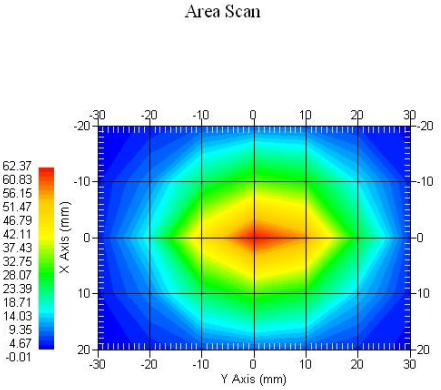


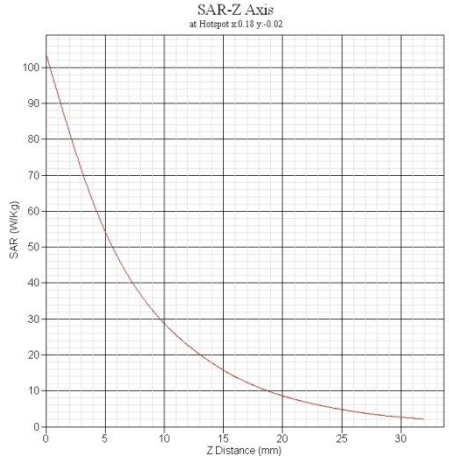
2100 MHz System Check





2450 MHz System check





System Check Uncertainty

Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	c_i^1 (1-g)	c_i^1 (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %
Measurement System							
Probe Calibration	3.5	normal	1	1	1	3.5	3.5
Axial Isotropy	3.7	rectangular	√3	$(1-cp)^{1/2}$	$(1-cp)^{1/2}$	1.5	1.5
Hemispherical Isotropy	10.9	rectangular	√3	√cp	√cp	4.4	4.4
Boundary Effect	1.0	rectangular	√3	1	1	0.6	0.6
Linearity	4.7	rectangular	√3	1	1	2.7	2.7
Detection Limit	1.0	rectangular	√3	1	1	0.6	0.6
Readout Electronics	1.0	normal	1	1	1	1.0	1.0
Response Time	0.8	rectangular	√3	1	1	0.5	0.5
Integration Time	1.7	rectangular	√3	1	1	1.0	1.0
RF Ambient Condition	3.0	rectangular	√3	1	1	1.7	1.7
Probe Positioner Mech.	0.4	rectangular	√3	1	1	0.2	0.2
Restriction							
Probe Positioning with respect to Phantom Shell	2.9	rectangular	√3	1	1	1.7	1.7
Extrapolation and Integration	3.7	rectangular	√3	1	1	2.1	2.1
Test Sample Positioning	4.0	normal	1	1	1	4.0	4.0
Device Holder Uncertainty	2.0	normal	1	1	1	2.0	2.0
Drift of Output Power	1.6	rectangular	√3	1	1	0.9	0.9
Phantom and Setup							
Phantom Uncertainty(shape & thickness tolerance)	3.4	rectangular	√3	1	1	2.0	2.0
Liquid Conductivity(target)	5.0	rectangular	√3	0.7	0.5	2.0	1.4
Liquid Conductivity(meas.)	1.4	normal	1	0.7	0.5	0.0	0.0
Liquid Permittivity(target)	5.0	rectangular	√3	0.6	0.5	1.7	1.4
Liquid Permittivity(meas.)	1.4	normal	1	0.6	0.5	0.0	0.0
Combined Uncertainty		RSS				9.3	9.1
Combined Uncertainty (coverage factor=2)		Normal(k=2)				18.6	18.2

6.2 Experimental Results Summary

The results for each experimental assessment are contained within this section. Where any deviation has been made from the given procedures contained within IEEE-1528, IEC62209-2, and FCC Supplement C this has been described accordingly.

6.3 SAR Measurement Procedure

The ALSAS-10U calculates SAR using the following equation,

$$SAR = \frac{\sigma |E|^2}{\rho}$$

σ: represents the simulated tissue conductivity
ρ: represents the tissue density

The DUT is set to transmit at the required power in line with product specification, at each frequency relating to the LOW, MID, and HIGH channel settings.

Pre-scans are made on the device to establish the location for the transmitting antenna, using a large area scan in either air or tissue simulation fluid.

The DUT is placed against the Universal Phantom where the maximum area scan dimensions are larger than the physical size of the resonating antenna. When the scan size is not large enough to cover the peak SAR distribution, it is modified by either extending the area scan size in both the X and Y directions, or the device is shifted within the predefined area.

The area scan is then run to establish the peak SAR location (interpolated resolution set at $1mm^2$) which is then used to orient the center of the zoom scan. The zoom scan is then executed and the 1g and 10g averages are derived from the zoom scan volume (interpolated resolution set at $1mm^3$).

6.4 SAR Exposure Limits

SAR assessments have been made in line with the requirements of the documents listed in section 2 of this report.

Type of Exposure	Uncontrolled Environment Limit
Spatial Peak SAR (1g cube tissue for brain or body)	**1.60 W/kg**
Spatial Average SAR (whole body)	**0.08 W/kg**
Spatial Peak SAR (10g for hands, feet, ankles and wrist)	**4.00 W/kg**

6.5 Equipment List

APREL utilize the following equipment.

Equipment Description	Asset/Serial Number	Calibration Due Date
ALSAS-10U	301571	Annual validation performed on January 16, 2017
Boundary Detection Unit	120-00261	November 2, 2017
Daq-Paq	110-00227	November 2, 2017
ALSAS-10U software	V2.5.2	Released on Jan 26, 2016
Signal Generator Agilent E4438C	MY45094463	December 11, 2017
Power Meter Tektronix USB	11C940	April 13, 2019
Network Analyzer Anritsu 37347C	002106	January 26, 2019
Agilent E5515C 8960 Series 10	GB45361013	January 12, 2018
HP-Directional Coupler	100251	In house check January 5, 2017
APREL 800-4200MHz 12W Amplifier	301577	In house check November 24, 2016
APREL E-020 E-Field Probe	225	November 4, 2017
APREL Uni-Flat Phantom	153-00101	In House Check on January 16, 2017
APREL Coaxial Probe (Dielectric Probe Kit)	300	CBT
Microwave TLR Calibration Kit	134	In House Check on January 16, 2017
APREL 15mm Dipole Separation Kit	301546	CBT
APREL 10mm Dipole Separation Kit	301547	CBT
APREL 5-6GHz 2 W Amplifier	301692	In House Check on January 12, 2017
APREL 835 MHz Validation Dipole	180-00554	November 3, 2017
APREL 900MHz Validation Dipole	190-00604	November 3, 2017
APREL 1800MHz Validation Dipole	200-00654	November 3, 2017
APREL 1900MHz Validation Dipole	210-00704	November 3, 2017
APREL 2100MHz Validation Dipole	217-00802	November 2, 2017
APREL 2450MHz Validation Dipole	220-00756	November 2, 2017
APREL MMW Directional Coupler	301569	In House Check on January 12, 2017
ALSAS-10 Device Positioner ALS-H-E-SET-2	170-00516	N/A

***CBT, Calibrate before Test, system validation**

7 SAR Measurement Results

7.1 W-CDMA

Power	Band 1: 21.5 dBm Band 2: 21.5 dBm Band 5: 23.0 dBm Band 8: 23.0 dBm
DUT Position	Front, back, side, bottom
Separation	5 mm
Antenna Type	Internal etched PIFA
Antenna Manufacturer	Flex
Antenna Location	Etched onto main circuit board, lower left corner of device when looking at device face
Mode	W-CDMA
Tx Frequency	Band 1: 1920-1980 MHz Band 2: 1850-1910 MHz Band 5: 824-849 MHz Band 8: 880-915 MHz
Duty Cycle	1:1
Tissue Depth	15mm
Phantom Type	Body
DUT Workstation Location	Centre
Device Positioner	UDP
Test Date	June 7, 2017 June 13, 2017
Test Engineer	Maryna Nesterova

NOTE:
Transmit Power was measured using a conducted method directly connected to the Base Station Communications test set.

Band 1

Channel	Position	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg @ 5mm Separation	Uncertainty, %
Low 10562	front	1.318	0.767	18.7
Mid 10700	front	1.137	0.659	19.1
High 10838	front	1.225	0.703	19.9
Low 10562	back	0.831	0.514	20.2
Low 10562	side	1.133	0.606	18.9
Low 10562	bottom	0.265	0.173	20.5

Band 2

Channel	Position	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg @ 5mm Separation	Uncertainty, %
Low 9662	front	1.168	0.677	18.9
Mid 9800	front	1.031	0.589	18.8
High 9938	front	0.97	0.569	19.7
Low 9662	back	1.006	0.608	19.1
Low 9662	side	0.924	0.528	19.7

Band 8

Channel	Position	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg @ 5mm Separation	Uncertainty, %
Low 2937	front	0.717	0.451	19.2
Mid 3012	front	0.886	0.551	19.5
High 3088	front	0.596	0.372	19.3
Mid 3012	back	0.502	0.300	19.8
Mid 3012	side	0.220	0.129	19.5

Band 5

Channel	Position	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg @ 5mm Separation	Uncertainty, %
Low 4357	front	0.432	0.216	19.8
Mid 4407	front	0.466	0.244	19.7
High 4458	front	0.168	0.112	20.2
Mid 4407	back	0.230	0.115	20.3
Mid 4407	side	0.118	0.098	20.5

SAR Limit		Highest Measured SAR @ 5mm Separation
1-g SAR	1.6 W/kg	1.318 W/kg
10-g SAR	2.0 W/kg	0.767

SAR Plot for Conservative SAR Included in Appendix A.

7.2 SAR Measurement Results GSM

Power	GSM850: 32.1 dBm EGSM: 32.2 dBm DCS 30.3 dBm PCS 30.3 dBm
DUT Position	Front, back, side
Separation	5 mm
Antenna Type	Internal etched PIFA
Antenna Manufacturer	Flex
Antenna Location	Etched onto main circuit board, lower left corner of device when looking at device face
Mode	GPRS
Tx Frequency Bands	GSM 850: 824.2-848.8 MHz EGSM 900: 880-915 MHz DCS1800: 1710.2-1784.8 MHz PCS1900: 1850.2-1909.8 MHz
Duty Cycle	GPRS 2:8
Tissue Depth	15mm
Phantom Type	Body
DUT Workstation Location	Centre
Device Positioner	UDP
Test Date	June 8, 2017 June 9, 2017
Test Engineer	Maryna Nesterova

NOTE:
Transmit Power was measured using a conducted method directly connected to the Base Station Communications test set.

GSM850

Channel	Position	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg @ 5mm Separation	Uncertainty, %
Low #128	Front	0.690	0.441	21.5
Mid #160	Front	0.686	0.447	19.8
High #251	Front	0.895	0.578	19.0
High #251	Back	0.516	0.392	19.6

EGSM

Channel	Position	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg @ 5mm Separation	Uncertainty, %
Low #1	Front	0.903	0.583	18.6
Mid #62	Front	0.545	0.314	19.8
High #251	Front	0.419	0.266	19.8
Low #251	Back	0.452	0.302	19.2

DCS

Channel	Position	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg @ 5mm Separation	Uncertainty, %
Low #512	Front	0.512	0.284	20.5
Mid #698	Front	0.515	0.282	20.1
High #885	Front	0.479	0.278	21.2
Mid #698	Back	0.357	0.228	21.5

PCS

Channel	Position	1g SAR, W/kg	10g SAR, W/kg	Uncertainty, %
Low #512	Front	0.679	0.391	20.1
Mid #661	Front	0.732	0.414	20.2
High #810	Front	0.685	0.405	20.2
Mid #661	Side	0.715	0.431	21.0

SAR Limit		Highest Measured SAR @ 5mm Separation
1-g SAR	1.6 W/kg	0.903 W/kg
10-g SAR	2.0 W/kg	0.583

SAR Report for Conservative SAR Included in Appendix A.

7.3 SAR Measurement Results WiFi

Power (measured)	Refer to table on pages 31 and 32
DUT Position	Front, back, side
Separation	5 mm
Antenna Type	Internal Chip antenna
Antenna Manufacturer	Pulse
Antenna Location	Surface mount chip antenna, lower right side of device when looking at device face
Mode	
Tx Frequency Bands	2412-2472 MHz for 802.11bgn
Duty Cycle	
Tissue Depth	15mm
Phantom Type	Body
DUT Workstation Location	Centre
Device Positioner	UDP
Test Date	June 8, 2017
Test Engineer	Maryna Nesterova

Power Measurements

Power Measurement Setup

Power measurements were taken using a power sensor connected directly to the antenna port of the DUT.

Mode	Channel	Frequency, MHz	BW, MHz	Rate	Max Input	Output
802.11b	1	2412	20	1	16 dBm	16.2
	6	2437	20	1		16.2
	11	2462	20	1		16.5
	13	2472	20	1		16.0
	1	2412	20	2	16 dBm	16.2
	6	2437	20	2		16.4
	11	2462	20	2		16.4
	13	2472	20	2		16.1
	1	2412	20	5.5	16 dBm	16.6
	6	2437	20	5.5		16.7
	11	2462	20	5.5		16.4
	13	2472	20	5.5		16.3
	1	2412	20	11	16 dBm	16.2
	6	2437	20	11		16.2
	11	2462	20	11		16.0
	13	2472	20	11		16.0

Mode	Channel	Frequency, MHz	BW, MHz	Rate	Max Input	Output
802.11g	1	2412	20	6	11 dBm	11.7
	6	2437	20	6		11.7
	11	2462	20	6		11.4
	13	2472	20	6		11.2
	1	2412	20	12	11 dBm	11.4
	6	2437	20	12		11.4
	11	2462	20	12		11.6
	13	2472	20	12		11.2
	1	2412	20	24	11 dBm	11.0
	6	2437	20	24		11.0
	11	2462	20	24		10.7
	13	2472	20	24		10.5
	1	2412	20	9	11 dBm	11.6
	6	2437	20	9		11.6
	11	2462	20	9		11.3
	13	2472	20	9		11.1
	1	2412	20	18	11 dBm	11.2
	6	2437	20	18		11.2
	11	2462	20	18		11.5
	13	2472	20	18		11.1
	1	2412	20	36	11 dBm	10.8
	6	2437	20	36		10.7
	11	2462	20	36		11.0
	13	2472	20	36		10.7
	1	2412	20	48	11 dBm	10.4
	6	2437	20	48		10.4
	11	2462	20	48		10.2
	13	2472	20	48		10.1
	1	2412	20	54	11 dBm	10.4
	6	2437	20	54		10.5
	11	2462	20	54		10.1
	13	2472	20	54		10.1

Mode	Channel	Frequency, MHz	BW, MHz	Rate	Max Input	Output
802.11n	1	2412	20	0	10	10.7
	6	2437	20	0	12	12.6
	11	2462	20	0	9	9.4
	13	2472	20	0	10	9.3
	1	2412	20	1	10	10.5
	6	2437	20	1	12	12.4
	11	2462	20	1	9	9.2
	13	2472	20	1	10	9.0
	1	2412	20	2	10	10.4
	6	2437	20	2	12	12.3
	11	2462	20	2	9	9.1
	13	2472	20	2	10	8.9
	1	2412	20	3	10	10.3
	6	2437	20	3	12	12.2
	11	2462	20	3	9	9.0
	13	2472	20	3	10	8.8
	1	2412	20	4	10	10.0
	6	2437	20	4	12	12.0
	11	2462	20	4	9	8.8
	13	2472	20	4	10	8.6
	1	2412	20	5	10	9.9
	6	2437	20	5	12	12.0
	11	2462	20	5	9	8.6
	13	2472	20	5	10	8.5
	1	2412	20	6	10	9.8
	6	2437	20	6	12	11.9
	11	2462	20	6	9	8.5
	13	2472	20	6	10	8.4
	1	2412	20	7	10	9.7
	6	2437	20	7	12	11.7
	11	2462	20	7	9	8.5
	13	2472	20	7	10	8.2

SAR measurements were performed for the highest power output channels; where the evaluated 1-g SAR values are lower than 0.4 W/kg (threshold) additional SAR testing is not required.

802.11n	Position	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg @ 5mm Separation	Uncertainty, %
Rate 0 Channel 6	Front	0.134	0.091	20.3
Rate 1 Channel 6	Front	0.159	0.099	20.7
Rate 1 Channel 6	Side	0.148	0.101	20.5

802.11b	Position	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg @ 5mm Separation	Uncertainty, %
Rate 5.5 Channel 6	Front	0.223	0.132	19.1
Rate 5.5 Channel 6	Front	0.150	0.099	20.1

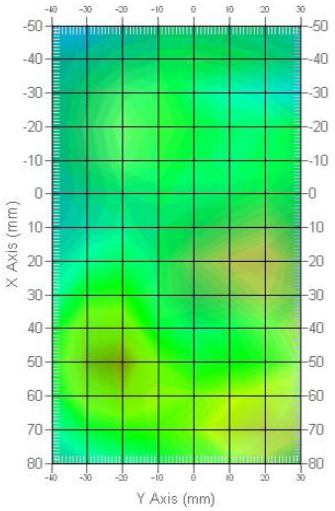
802.11g	Position	1g SAR, W/kg @ 5mm Separation	10g SAR, W/kg @ 5mm Separation	Uncertainty, %
Rate 6 Channel 1	Front	0.157	0.100	19.7
Rate 6 Channel 1	Front	0.114	0.086	21.5

SAR Limits		Highest Measured SAR @ 5mm Separation
1-g SAR	1.6 W/kg	0.223 W/kg
10-g SAR	2.0 W/kg	0.132 W/kg

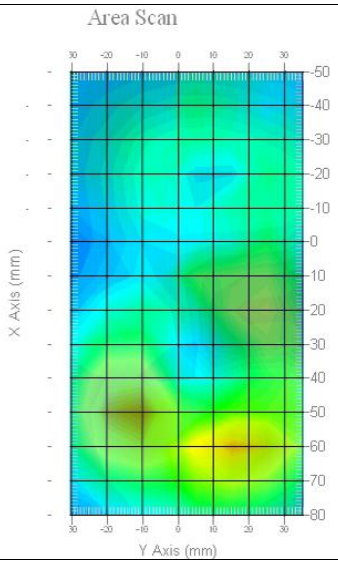
SAR Report for Conservative SAR Included in Appendix A.

7.4 Combined SAR for Simultaneous Transmission

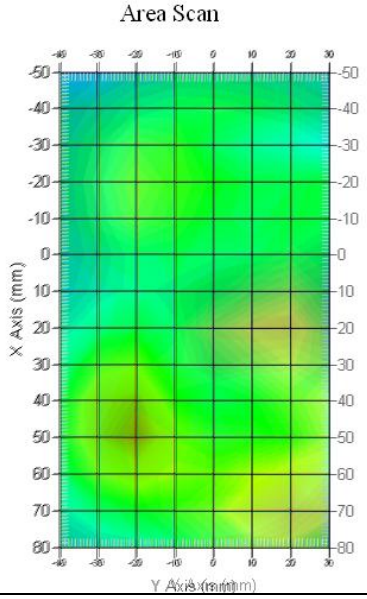
For the evaluation of combined SAR for simultaneous transmission of W-CDMA and WiFi signals the approximated 1-g average SAR was calculated for every point of combined plots. The maximum value is reported in the table below.



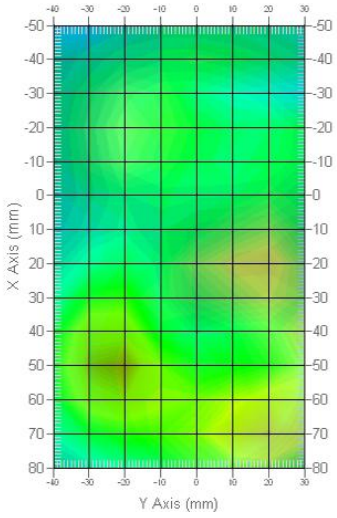
W-CDMA Band 1 combined with WiFi 802.11b



W-CDMA Band 1 combined with WiFi 802.11g



W-CDMA Band 2 combined with WiFi 802.11b



W-CDMA Band 2 combined with WiFi 802.11g

		1g SAR, W/kg @ 0.5mm Separation	St Deviation for 1-g SAR approximation formula
WiFi 802.11b Rate 5.5 Channel 6	W-CDMA 1	1.39	1.04 %
WiFi 802.11b Rate 5.5 Channel 6	W-CDMA 2	1.24	1.05 %
WiFi 802.11g Rate 6 Channel 1	W-CDMA 1	1.34	0.55 %
WiFi 802.11g Rate 6 Channel 1	W-CDMA 2	1.19	0.56 %

APPENDIX A

SAR Reports

Report Date : 13-Jun-2017
By Operator : Maryna Nesterova
Measurement Date : 13-Jun-2017
Starting Time : 13-Jun-2017 01:37:53 PM
End Time : 13-Jun-2017 01:57:39 PM
Scanning Time : 1186 secs
Product Data
Device Name : Austonio
Serial No. : FZAUS171100020
Type : Other
Model : V1
Frequency : 2100 MHz
Max. Transmit Pwr : 1 W
Drift Time : 5 min(s)
Length : 129 mm
Width : 65 mm
Depth : 25 mm
Antenna Type : Internal
Power Drift-Start : 0.247 W/kg
Power Drift-Finish: 0.257 W/kg
Power Drift (%) : 3.791

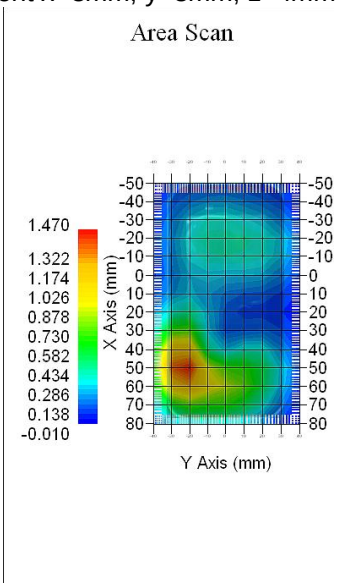
Phantom Data
Name : APREL Uni-Flat
Type : Body
Size (mm) : 264 x 332 x 220
Location : Center

Tissue Data
Type : BODY
Frequency : 2100.00 MHz
Last Calib. Date : 13-Jun-2017
Temperature : 21.00 °C
Ambient Temp. : 22.00 °C
Humidity : 48.00 RH%
Epsilon (Dielectric Constant): 52.78
Sigma : 1.58 S/m
Density : 1000.00 kg/cu. M

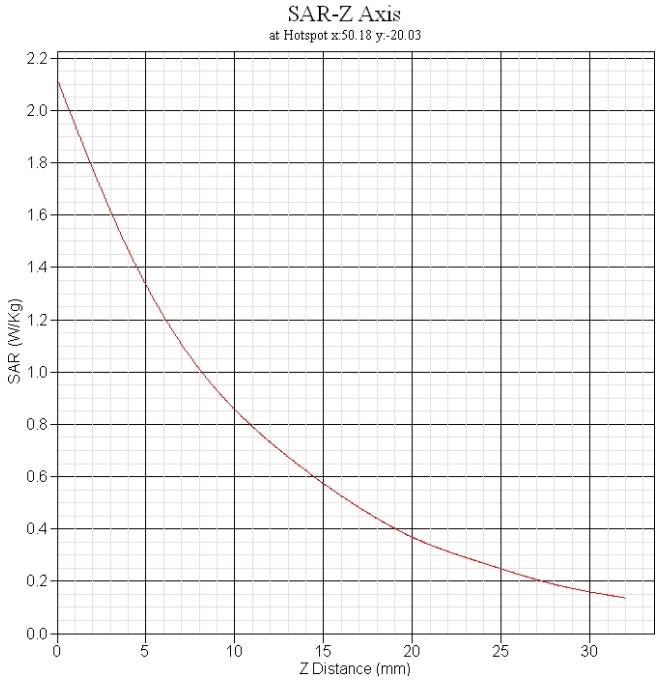
Probe Data
Name : E020 APREL
Model : E020
Type : E-Field Triangle
Serial No. : 225
Last Calib. Date : 04-Oct-2016
Frequency : 2100.00 MHz
Duty Cycle Factor (CreF): 1
Conversion Factor : 5.1
Probe Sensitivity : 1.20 1.20 1.20 $\mu V/(V/m)^2$
Compression Point : 95.00 mV
Offset : 1.56 mm

Measurement Data
Crest Factor : 1

Area Scan : 14x9x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan : 5x5x8 : Measurement x=8mm, y=8mm, z=4mm



Area Scan Peak SAR : 1.451 W/kg
Area Scan Peak SAR coordinates: X = 50.180, Y = -20.030
The system detected 1 maxima.
Selected highest maxima # = 1.
Maxima #1 coordinates: X = 50.180, Y = -20.000
Zoom Scan Peak SAR : 2.121 W/kg
1 gram SAR value : 1.318 W/kg
10 gram SAR value : 0.767 W/kg



Exposure Assessment Measurement Uncertainty

Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	c_i^1 (1-g)	c_i^1 (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %
Measurement System							
Probe Calibration	3.5	normal	1	1	1	3.5	3.5
Axial Isotropy	3.7	rectangular	√3	$(1-cp)^{1/2}$	$(1-cp)^{1/2}$	1.5	1.5
Hemispherical Isotropy	10.9	rectangular	√3	√cp	√cp	4.4	4.4
Boundary Effect	1.0	rectangular	√3	1	1	0.6	0.6
Linearity	4.7	rectangular	√3	1	1	2.7	2.7
Detection Limit	1.0	rectangular	√3	1	1	0.6	0.6
Readout Electronics	1.0	normal	1	1	1	1.0	1.0
Response Time	0.8	rectangular	√3	1	1	0.5	0.5
Integration Time	1.7	rectangular	√3	1	1	1.0	1.0
RF Ambient Condition	3.0	rectangular	√3	1	1	1.7	1.7
Probe Positioner Mech.	0.4	rectangular	√3	1	1	0.2	0.2
Restriction							
Probe Positioning with respect to Phantom Shell	2.9	rectangular	√3	1	1	1.7	1.7
Extrapolation and Integration	3.7	rectangular	√3	1	1	2.1	2.1
Test Sample Positioning	4.0	normal	1	1	1	4.0	4.0
Device Holder Uncertainty	2.0	normal	1	1	1	2.0	2.0
Drift of Output Power	3.8	rectangular	√3	1	1	2.2	2.2
Phantom and Setup							
Phantom Uncertainty(shape & thickness tolerance)	3.4	rectangular	√3	1	1	2.0	2.0
Liquid Conductivity(target)	5.0	rectangular	√3	0.7	0.5	2.0	1.4
Liquid Conductivity(meas.)	1.4	normal	1	0.7	0.5	0.0	0.0
Liquid Permittivity(target)	5.0	rectangular	√3	0.6	0.5	1.7	1.4
Liquid Permittivity(meas.)	1.4	normal	1	0.6	0.5	0.0	0.0
Combined Uncertainty		RSS				9.5	9.3
Combined Uncertainty (coverage factor=2)		Normal(k=2)				19.0	18.7

Report Date : 08-Jun-2017

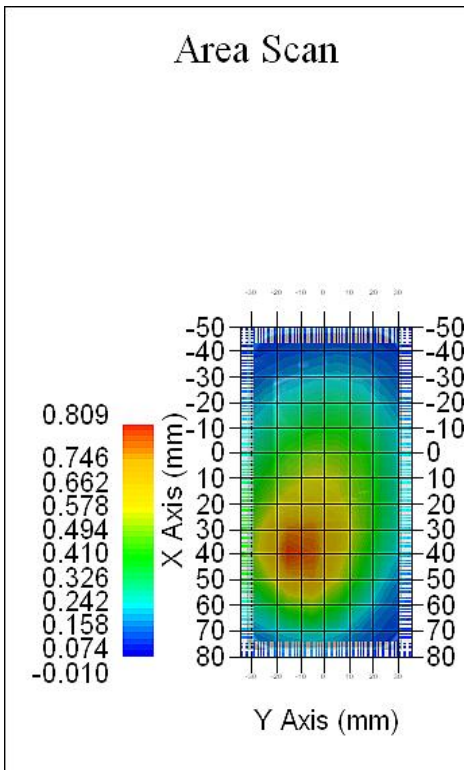
By Operator : Maryna Nesterova
Measurement Date : 08-Jun-2017
Starting Time : 08-Jun-2017 08:04:16 PM
End Time : 08-Jun-2017 08:22:41 PM
Scanning Time : 1105 secs
Product Data
Device Name : Austonio
Serial No. : FZAUS171100020
Model : V1
Frequency : 900 MHz
Max. Transmit Pwr : 1 W
Drift Time : 5 min(s)
Length : 129 mm
Width : 65 mm
Depth : 25 mm
Antenna Type : Internal
Power Drift-Start : 0.742 W/kg
Power Drift-Finish: 0.720 W/kg
Power Drift (%) : -2.988

Phantom Data
Name : APREL Uni-Flat
Type : Body
Size (mm) : 264 x 332 x 220
Location : Center

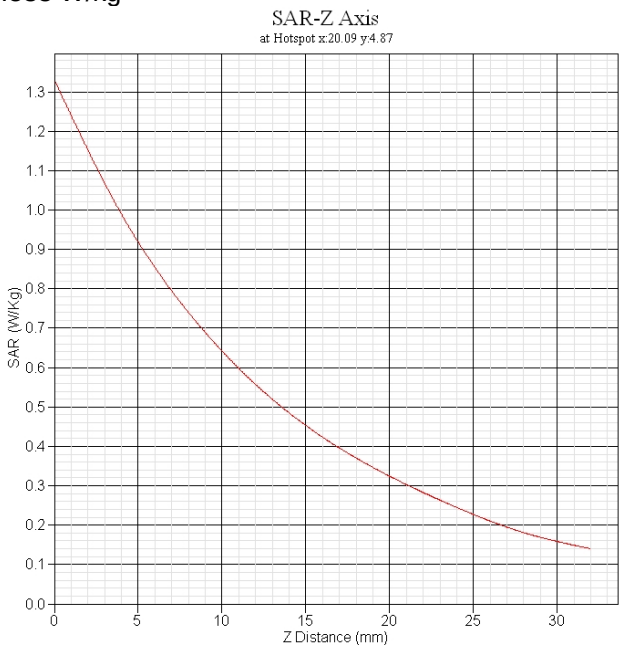
Tissue Data
Type : BODY
Frequency : 900.00 MHz
Last Calib. Date : 07-Jun-2017
Temperature : 22.00 °C
Ambient Temp. : 21.00 °C
Humidity : 41.00 RH%
Epsilon (Dielectric Constant): 53.70
Sigma : 1.05 S/m
Density : 1000.00 kg/cu. M

Probe Data
Name : E020 APREL
Type : E-Field Triangle
Serial No. : 225
Last Calib. Date : 04-Oct-2016
Frequency : 900.00 MHz
Duty Cycle Factor (CreF): 4
Conversion Factor : 6.5
Probe Sensitivity : 1.20 1.20 1.20 $\mu V/(V/m)^2$
Compression Point : 95.00 mV
Offset : 1.56 mm

Measurement Data
Crest Factor : 4
Scan Type : Complete
Area Scan : 7x7x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan : 5x5x8 : Measurement x=8mm, y=8mm, z=4mm



Area Scan Peak SAR : 0.998 W/kg
Area Scan Peak SAR coordinates: X = 20.090, Y = 4.870
The system detected 1 maxima.
Selected highest maxima # = 1.
Maxima #1 coordinates: X = 20.090, Y = 4.800
Zoom Scan Peak SAR : 1.331 W/kg
1 gram SAR value : 0.903 W/kg
10 gram SAR value : 0.583 W/kg



Exposure Assessment Measurement Uncertainty

Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	c_i^1 (1-g)	c_i^1 (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %
Measurement System							
Probe Calibration	3.5	normal	1	1	1	3.5	3.5
Axial Isotropy	3.7	rectangular	√3	$(1-cp)^{1/2}$	$(1-cp)^{1/2}$	1.5	1.5
Hemispherical Isotropy	10.9	rectangular	√3	√cp	√cp	4.4	4.4
Boundary Effect	1.0	rectangular	√3	1	1	0.6	0.6
Linearity	4.7	rectangular	√3	1	1	2.7	2.7
Detection Limit	1.0	rectangular	√3	1	1	0.6	0.6
Readout Electronics	1.0	normal	1	1	1	1.0	1.0
Response Time	0.8	rectangular	√3	1	1	0.5	0.5
Integration Time	1.7	rectangular	√3	1	1	1.0	1.0
RF Ambient Condition	3.0	rectangular	√3	1	1	1.7	1.7
Probe Positioner Mech.	0.4	rectangular	√3	1	1	0.2	0.2
Restriction							
Probe Positioning with respect to Phantom Shell	2.9	rectangular	√3	1	1	1.7	1.7
Extrapolation and Integration	3.7	rectangular	√3	1	1	2.1	2.1
Test Sample Positioning	4.0	normal	1	1	1	4.0	4.0
Device Holder Uncertainty	2.0	normal	1	1	1	2.0	2.0
Drift of Output Power	3.0	rectangular	√3	1	1	1.7	1.7
Phantom and Setup							
Phantom Uncertainty(shape & thickness tolerance)	3.4	rectangular	√3	1	1	2.0	2.0
Liquid Conductivity(target)	5.0	rectangular	√3	0.7	0.5	2.0	1.4
Liquid Conductivity(meas.)	0.0	normal	1	0.7	0.5	0.0	0.0
Liquid Permittivity(target)	5.0	rectangular	√3	0.6	0.5	1.7	1.4
Liquid Permittivity(meas.)	2.4	normal	1	0.6	0.5	1.4	1.2
Combined Uncertainty		RSS				9.5	9.3
Combined Uncertainty (coverage factor=2)		Normal(k=2)				19.0	18.6

Project 5838
FCC ID: QQD-EC3331

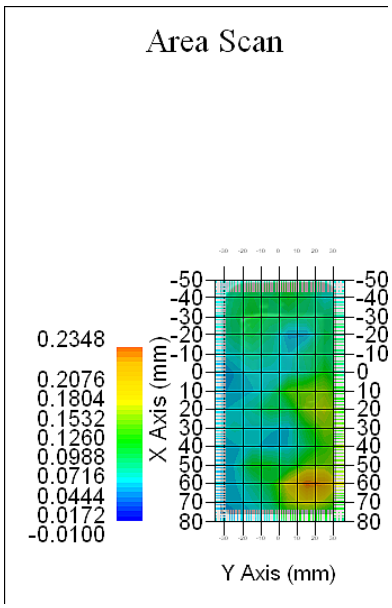
Report Date : 09-Jun-2017
By Operator : Maryna Nesterova
Measurement Date : 09-Jun-2017
Starting Time : 09-Jun-2017 03:50:42 PM
End Time : 09-Jun-2017 04:09:00 PM
Scanning Time : 1098 secs
Product Data
Device Name : Austonio
Serial No. : FZAUS171100020
Type : Other
Model : V1
Frequency : 2437 MHz
Max. Transmit Pwr : 1 W
Drift Time : 5 min(s)
Length : 129 mm
Width : 65 mm
Depth : 25 mm
Antenna Type : Internal
Power Drift-Start : 0.062 W/kg
Power Drift-Finish: 0.065 W/kg
Power Drift (%) : 4.8

Phantom Data
Name : APREL Uni-Flat
Type : Body
Size (mm) : 264 x 332 x 220
Location : Center

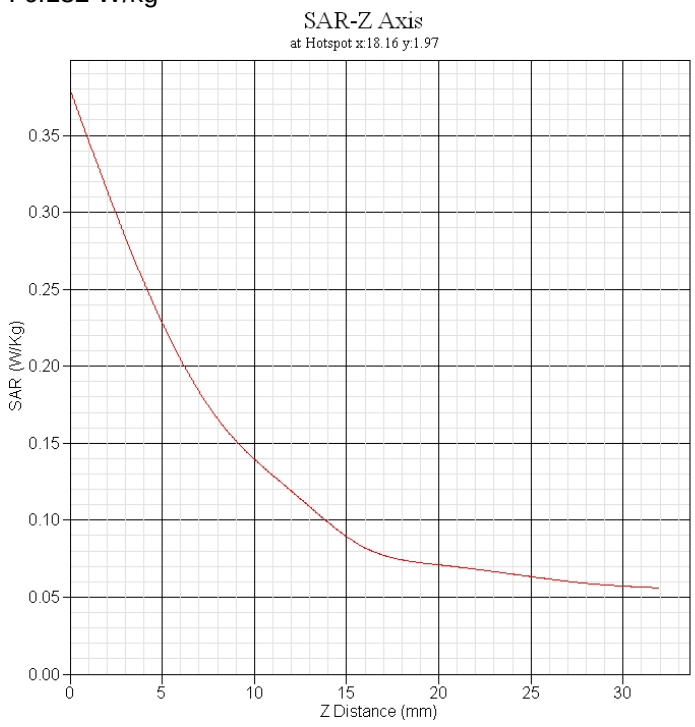
Tissue Data
Type : BODY
Serial No. : 2450B
Frequency : 2450.00 MHz
Last Calib. Date : 08-May-2017
Temperature : 22.00 °C
Ambient Temp. : 22.00 °C
Humidity : 41.00 RH%
Epsilon (Dielectric Constant): 53.59
Sigma : 1.90 S/m
Density : 1000.00 kg/cu. M

Probe Data
Name : E020 APREL
Type : E-Field Triangle
Serial No. : 225
Last Calib. Date : 04-Oct-2016
Frequency : 2450.00 MHz
Duty Cycle Factor (CreF): 1
Conversion Factor : 4.7
Probe Sensitivity : 1.20 1.20 1.20 $\mu V/(V/m)^2$
Compression Point : 95.00 mV
Offset : 1.56 mm

Measurement Data
Crest Factor : 1
Scan Type : Complete
Area Scan : 14x8x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan : 5x5x8 : Measurement x=8mm, y=8mm, z=4mm



Area Scan Peak SAR : 0.246 W/kg
Area Scan Peak SAR coordinates: X = 10.160, Y = 9.970
The system detected 1 maxima.
Selected highest maxima # = 1.
Maxima #1 coordinates: X = 18.160, Y = 1.900
Zoom Scan Peak SAR : 0.380 W/kg
1 gram SAR value : 0.223 W/kg
10 gram SAR value : 0.132 W/kg



Exposure Assessment Measurement Uncertainty

Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	c_i^1 (1-g)	c_i^1 (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %
Measurement System							
Probe Calibration	3.5	normal	1	1	1	3.5	3.5
Axial Isotropy	3.7	rectangular	√3	$(1-cp)^{1/2}$	$(1-cp)^{1/2}$	1.5	1.5
Hemispherical Isotropy	10.9	rectangular	√3	√cp	√cp	4.4	4.4
Boundary Effect	1.0	rectangular	√3	1	1	0.6	0.6
Linearity	4.7	rectangular	√3	1	1	2.7	2.7
Detection Limit	1.0	rectangular	√3	1	1	0.6	0.6
Readout Electronics	1.0	normal	1	1	1	1.0	1.0
Response Time	0.8	rectangular	√3	1	1	0.5	0.5
Integration Time	1.7	rectangular	√3	1	1	1.0	1.0
RF Ambient Condition	3.0	rectangular	√3	1	1	1.7	1.7
Probe Positioner Mech.	0.4	rectangular	√3	1	1	0.2	0.2
Restriction							
Probe Positioning with respect to Phantom Shell	2.9	rectangular	√3	1	1	1.7	1.7
Extrapolation and Integration	3.7	rectangular	√3	1	1	2.1	2.1
Test Sample Positioning	4.0	normal	1	1	1	4.0	4.0
Device Holder Uncertainty	2.0	normal	1	1	1	2.0	2.0
Drift of Output Power	4.8	rectangular	√3	1	1	0.3	3.5
Phantom and Setup							
Phantom Uncertainty(shape & thickness tolerance)	3.4	rectangular	√3	1	1	2.0	2.0
Liquid Conductivity(target)	5.0	rectangular	√3	0.7	0.5	2.0	1.4
Liquid Conductivity(meas.)	2.6	normal	1	0.7	0.5	1.8	1.3
Liquid Permittivity(target)	5.0	rectangular	√3	0.6	0.5	1.7	1.4
Liquid Permittivity(meas.)	1.7	normal	1	0.6	0.5	1.0	0.8
Combined Uncertainty		RSS				9.5	9.2
Combined Uncertainty (coverage factor=2)		Normal(k=2)				18.9	19.1

APPENDIX B

Low Power Disclaimer

Edge Computing Gateway – EC3331
FCC ID: QQD-EC3331
IC:5248S-EC3331

Flex attest to the following exclusions for the assessment of the device FCC ID: **QQD-EC3331, IC: 5248S-EC3331,** regarding the additional transmit modes for simultaneous transmissions.

Based on the measurement standards and FCC KDB test references listed below additional SAR testing was excluded from the assessment.

1) Frequency Exclusion (less than 30MHz)
IEC 62209-2:2010 Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
Near Field Communication Radio (NFC) – NXP - PN7120
Transmit Frequency: 13.56 MHz
Transmitter Power: Typically, 45-55dBuV/m@10m (approx.-33dBm erp)
Low duty cycle TX on time.

2) Low Power Exclusion (less than 10mW combined with antenna gain)
OET Laboratory Division FCC KDB 447498 Mobile and Portable Device RF Exposure Equipment Authorization Procedures
Bluetooth 4.0/BLE Radio
Transmit frequency: 2400-2483.5 MHz
Transmit Power: +6.9dBm (0.0049W)
Max. Antenna Gain: +2.3dBi (0.0017W)

3) Low Power Exclusion (less than 16mW combined with antenna gain)
OET Laboratory Division FCC KDB 447498 Mobile and Portable Device RF Exposure Equipment Authorization Procedures
3. Z-Wave, Sigma Designs, ZM5202
Transmit frequency: 865.2-926.3 MHz
Transmit Power: +4.0dBm (0.0025W)
Max. Antenna Gain: -1.28dBi

It is the conclusion of Flex that simultaneous assessment for the above named transmit modes is not required as part of this analysis due to the low power and frequency exclusions.

Regards, Steve Tippet

Senior Manager – Product Integrity

APPENDIX C

ISO17025 Accreditation Certificate

CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board
500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

APREL Inc.
303 Terry Fox Drive, Suite 102
Ottawa, Ontario K2K 3J1 Canada

has been assessed by ANAB
and meets the requirements of international standard

ISO/IEC 17025:2005

while demonstrating technical competence in the field(s) of

TESTING

Refer to the accompanying Scope(s) of Accreditation for information regarding the types of tests to which this accreditation applies.

AT-1810
Certificate Number

ANAB Approval

Certificate Valid To: 10/01/2017
Version No. 001 Issued: 11/17/2015

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated January 2009*).

APPENDIX D

Calibration Reports

Project 5838
FCC ID: QQD-EC3331

NCL CALIBRATION LABORATORIES

Calibration File No.: DPC-1727

C E R T I F I C A T E OF C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

Equipment: DAQ-PAQ

Manufacturer: APREL Laboratories
Model No.: ALS-DAQ-PAQ-3
Serial No.: 110-00227

Calibration Procedure: SSI/DRB-TP-Daq-Paq-ALS-002
Project No:

Calibrated: 2nd November 2016
Released on: 2nd November 2016

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: _____

Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES
Suite 102, 303 Terry Fox Dr,
OTTAWA, ONTARIO
CANADA K2K 3J1
Division of APREL Lab.
TEL: (613) 435-8300
FAX: (613) 435-8306

Conditions

Daq-Paq 110-00227 was a re-calibration.

Ambient Temperature of the Laboratory: 21 °C +/- 0.5°C

Measurement Standards

Instrument	Serial Number	Check-in-house Date
APREL Load Resistance Kit	ALS106	November. 25, 2016

We the undersigned attest that to the best of our knowledge the calibration of this DAQ-PAQ has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.

Art Brennan, Quality Manager

Constantin Teodorian, Test Engineer

Introduction

This Calibration Report reproduces the results of the calibration performed in line with the SSI/DRB-TP-Daq-Paq-ALS-002 Calibration Procedure. The results contained within this report are used in conjunction with the source signal test set. The Daq-Paq has also been calibrated and validated in line with IEEE-1528, IEC 62209 – 1&2, and EN 50361 system validation procedures, and has been proven compliant.

References

- IEEE Standard 1528:2013
  IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- IEC 62209-1:2006
  Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models. instrumentation, and procedures - Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices
- IEC 62209-2:2010
  Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
- EN 50361 – 2001
  Basic Standard For The Measurement Of Specific Absorption Rate Related To Human Exposure To Electromagnetic Fields From Mobile Phones (300 Mhz-3 GHz)
- SSI/DRB-TP-Daq-Paq-ALS-002
  Daq-Paq Calibration Procedure

7.4.1.1.1

DAQ-PAQ calibration procedure was performed utilizing the 5 MΩ impedance load.

Response time of the electronics is evaluated independently of the probe using a closed loop conducted method to ensure the DC voltage is not clipped when switching between gain settings as the amplitude of the DC signal is increased. Typical response time between reading the voltage and setting the amplifier gain is 1µsec, and a sequence of samples is taken over a period of 1 sec to determine the signal being measured. The amplifier gain switching can be set to zero automatically within any period after the 100 µsec acquisition to ensure the proper amplifier gain is used in the measurement.

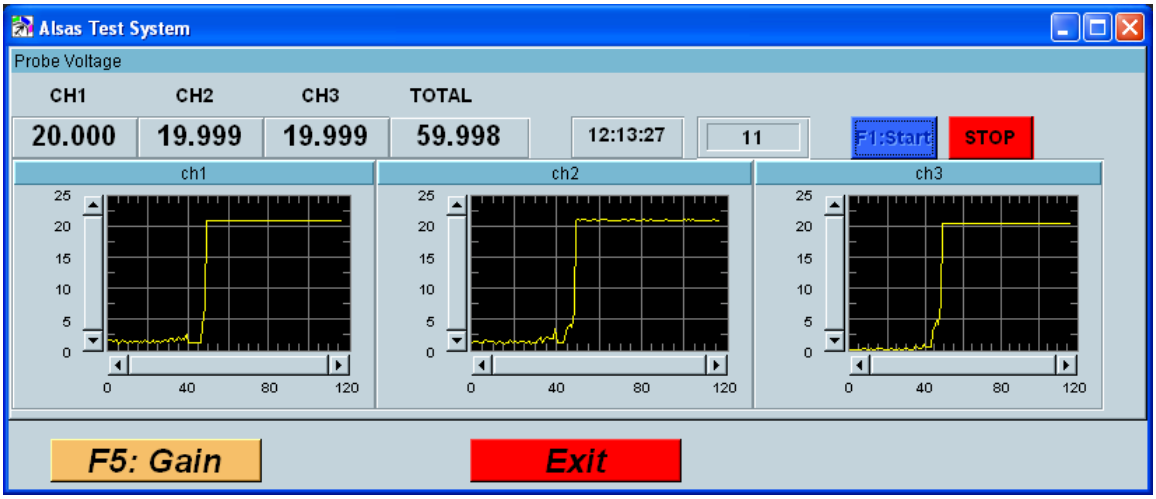
Test 1: ADC reference	
ADC reference (V):	2.502
Pass/Fail (2.50 V +/- 0.05):	Pass

Test 2: Internal Noise Test			
(Probe Input shorted) U1_p14:			14.889
	Input (mV)	Output (mV)	
Ch1	0.001	14.883	
Ch2	0.002	14.787	
Ch3	0.001	14.888	
	Input (mV)	Output (mV)	S1 Gain
Ch1	20	406.08	19.54335
Ch2	20	406.20	19.56815
Ch3	20	406.05	19.54241
Pass/Fail (19.5 ± 0.1)			Pass

Test 3: Amplifier S1 Gain Calibration							
	Input (mV)	output (mV)			S1 Gain		
		Ch1	Ch2	Ch3	Ch1	Ch2	Ch3
SUM1	0	14.881	14.785	14.890	19.5	19.6	19.5
SUM2	1.01	34.6366	34.6012	34.636	19.56	19.62	19.55
SUM3	10.01	210.4764	211.3814	211.086	19.54	19.64	19.6
SUM4	20.01	406.2766	406.3807	406.286	19.56	19.57	19.56
SUM5	40.02	795.271	798.7768	797.281	19.5	19.59	19.55
SUM6	50.02	990.7712	997.1778	994.782	19.51	19.64	19.59
SUM7	100.01	1970.077	1973.981	1969.085	19.55	19.59	19.54
SUM8	200.01	3925.077	3930.981	3917.085	19.55	19.58	19.51
SUM9	400.03	7823.467	7843.372	7827.476	19.52	19.57	19.53
SUM10	800.02	15623.27	15687.18	15647.281	19.51	19.59	19.54
Pass/Fail (19.5 +/- 0.5):					Pass		

Test 4: Amplifier S2 Gain Calibration (daq_test_Shift1.vxe)				
	Target Output (mV)	S1 gain	S2 Gain	S2 output (mV)
Ch1	20.000	19.5	1.230	20.000
Ch2	20.000	19.6	1.430	19.999
Ch3	20.000	19.5	0.660	19.999
			Channel Sum (mV):	59.998
			Pass/Fail (+/- 0.10 mV):	PASS

20 mV Load Readings



Uncertainty

Uncertainty component	Tolerance (± %)	Probability distribution	Divisor	Standard uncertainty (± %)
Amplification	**0.77**	R	√3	0.44
Linearity	**1.32**	R	√3	0.76
Loading	**0.81**	R	√3	0.47
Analog to digital converter	**0.78**	R	√3	0.45
Combined standard uncertainty		**RSS**		**1.0**

NCL CALIBRATION LABORATORIES

Calibration File No.: PC-1728

C E R T I F I C A T E OF C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

Equipment: Miniature Isotropic RF Probe
Record of Calibration
Head and Body
Manufacturer: APREL Inc.
Model No.: ALS-E020
Serial No.: 225

Calibration Procedure:
D01-032-E020-V2,
D22-012-Tissue,
D28-002-Dipole

Calibrated: 4th November 2016
Released on: 4th November 2016

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: _____

Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES
Suite 102, 303 Terry Fox Dr,
OTTAWA, ONTARIO
CANADA K2K 3J1
Division of APREL Lab.
TEL: (613) 435-8300
FAX: (613) 435-8306

Introduction

This Calibration Report reproduces the results of the calibration performed in line with the references listed below. Calibration is performed using accepted methodologies as per the references listed below. Probes are calibrated for air, and tissue and the values reported are the results from the physical quantification.

Calibration Method

Probes are calibrated using the following methods.

<800 MHz
TEM Cell for sensitivity in air
Standard phantom using temperature transfer method for sensitivity in tissue

>800 MHz
Waveguide* method to determine sensitivity in air and tissue
*Waveguide is numerically (simulation) assessed to determine the field distribution and power

The boundary effect for the probe is assessed using a standard flat phantom where the probe output is compared against a numerically simulated series of data points

References

- IEEE Standard 1528:2013
  IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- IEC 62209-1:2006
  Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models. instrumentation, and procedures - Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices
- IEC 62209-2:2010
  Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
- TP-D01-032-E020-V2 E-Field probe calibration procedure
- D22-012-Tissue dielectric tissue calibration procedure
- D28-002-Dipole procedure for validation of SAR system using a dipole
- IEEE 1309 Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

Conditions

Probe SN 225 was a recalibration.

Ambient Temperature of the Laboratory:	20 °C +/- 1.5°C
Temperature of the Tissue:	21 °C +/- 1.5°C
Relative Humidity:	< 60%

Primary Measurement Standards

Instrument	Serial Number	Cal due date
Power Meter Tektronix USB	11C940	Apr 2, 2017
Signal Generator Agilent E4438C	MY45094463	Dec 11, 2017

Secondary Measurement Standards

Network Analyzer Anritsu 37347C	002106	Feb. 4, 2017

Attestation

The below named signatories have conducted the calibration and review of the data which is presented in this calibration report.

Attestation

The below named signatories have conducted the calibration and review of the data which is presented in this calibration report.

We the undersigned attest that to the best of our knowledge the calibration of this subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.

Art Brennan, Quality Manager

Maryna Nesterova Calibration Engineer

Probe Summary

Probe Type:	E-Field Probe E-020
Serial Number:	225
Frequency:	As presented on page 5
Sensor Offset:	1.56
Sensor Length:	2.5
Tip Enclosure:	Composite*
Tip Diameter:	< 2.9 mm
Tip Length:	55 mm
Total Length:	289 mm
Diode Compression Point:	95 mV

Sensitivity in Air

Frequency Range	**Channel X,** $\mu V/(V/m)^2$	**Channel Y,** $\mu V/(V/m)^2$	**Channel Z,** $\mu V/(V/m)^2$	**Tolerance,** $\mu V/(V/m)^2$
150 MHz	1.211	1.201	1.199	±0.004
450 MHz	1.210	1.202	1.199	±0.004
750 MHz, 835 MHz 900 MHz	1.198	1.199	1.201	±0.004
1 GHz – 4 GHz	1.199	1.201	1.203	±0.004
5 GHz – 6 GHz	1.198	1.198	1.194	±0.005

*Resistive to recommended tissue recipes per IEEE-1528

Calibration for Tissue (Head H, Body B)

Frequency, MHz	Tissue Type	Measured Epsilon	Measured Sigma	Standard Uncertainty (%)	Calibration Frequency Range (MHz)	Conversion Factor
150 H	Head	49.81	0.77	3.5	±50	6.2
150 H	Body	61.32	0.88	3.5	±50	6.0
450 H	Head	45.67	086	3.5	±50	6.5
450 B	Body	56.86	0.89	3.5	±50	6.5
750 H	Head	43.70	0.91	3.5	±50	6.3
750 B	Body	56.98	0.96	3.5	±50	6.4
835 H	Head	43.44	0.94	3.5	±50	6.6
835 B	Body	54.55	1.00	3.5	±50	6.5
900 H	Head	39.54	1.00	3.5	±50	6.4
900 B	Body	55.16	1.04	3.5	±50	6.5
1450 H	Head	X	X	X	X	X
1450 B	Body	X	X	X	X	X
1500 H	Head	X	X	X	X	X
1500 B	Body	X	X	X	X	X
1640 H	Head	X	X	X	X	X
1640 B	Body	X	X	X	X	X
1750 H	Head	38.98	1.39	3.5	±75	5.8
1750 B	Body	53.55	1.48	3.5	±75	5.6
1800 H	Head	39.24	1.41	3.5	±75	5.5
1800 B	Body	53.90	1.49	3.5	±75	5.2
1900 H	Head	39.44	1.41	3.5	±75	5.2
1900 B	Body	53.55	1.59	3.5	±75	5.2
2000 H	Head	X	X	X	X	X
2000 B	Body	X	X	X	X	X
2100 H	Head	39.17	1.55	3.5	±75	5.2
2100 B	Body	52.71	1.66	3.5	±75	5.1
2300 H	Head	X	X	X	X	X
2300 B	Body	X	X	X	X	X
2450 H	Head	38.34	1.86	3.5	±75	4.8
2450B	Body	53.65	1.94	3.5	±75	4.7
3000 H	Head	37.86	2.00	3.5	±75	5.0
3000 B	Body	53.61	2.26	3.5	±75	4.8
3600 H	Head	37.25	3.14	3.5	±100	4.1
3600 B	Body	50.51	3.85	3.5	±100	4.0
5250 H	Head	34.19	4.78	3.5	±100	3.1
5250 B	Body	44.21	5.58	3.5	±100	2.7
5600 H	Head	33.98	5.27	3.5	±100	3.0
5600 B	Body	46.98	5.75	3.5	±100	2.6
5800 H	Head	33.98	5.50	3.5	±100	3.1
5800 B	Body	46.17	6.06	3.5	±100	2.6

Boundary Effect:

Uncertainty resulting from the boundary effect is less than 2.1% for the distance between the tip of the probe and the tissue boundary, when less than 0.58mm.

Spatial Resolution:

The spatial resolution uncertainty is less than 1.5% for 4.9mm diameter probe.
The spatial resolution uncertainty is less than 1.0% for 2.5mm diameter probe.

DAQ-PAQ Contribution

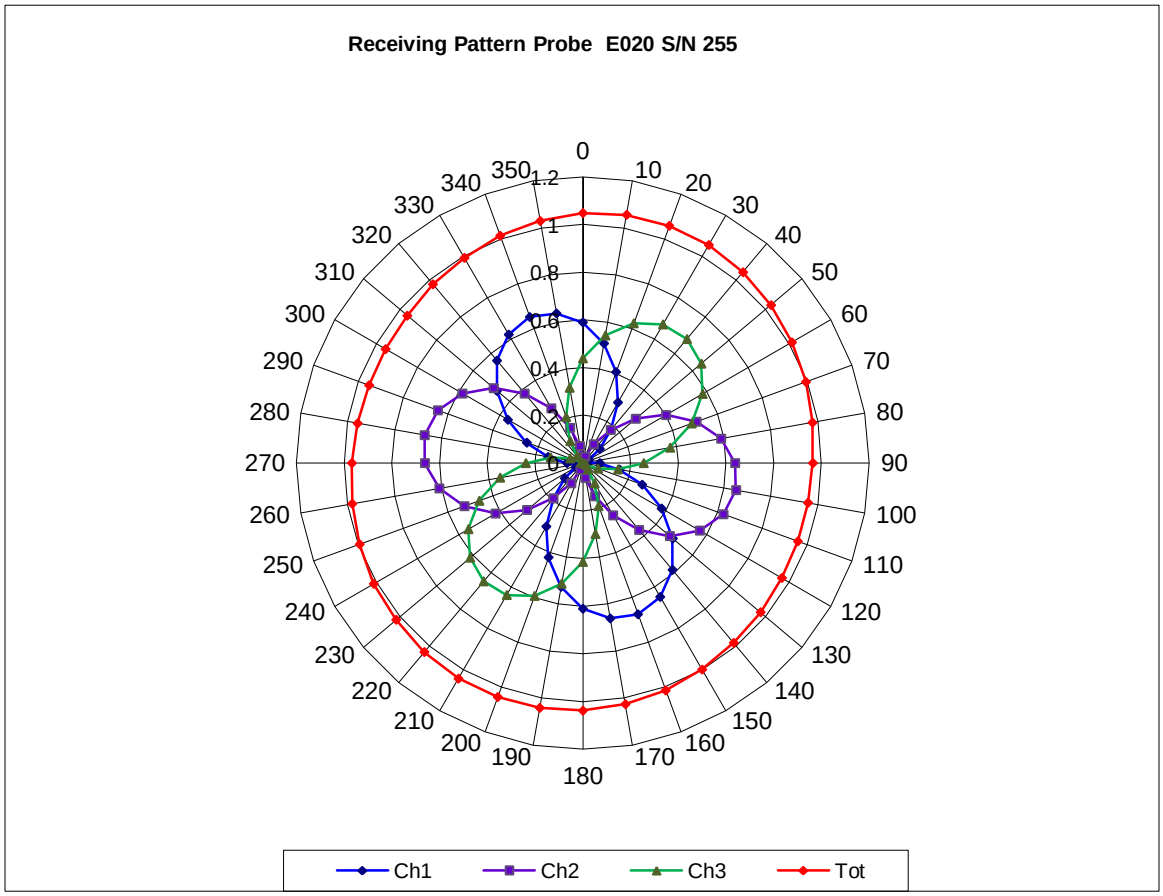
To minimize the uncertainty calculation all tissue sensitivity values were calculated using a load impedance of 5 MΩ.

Probe Calibration Uncertainty

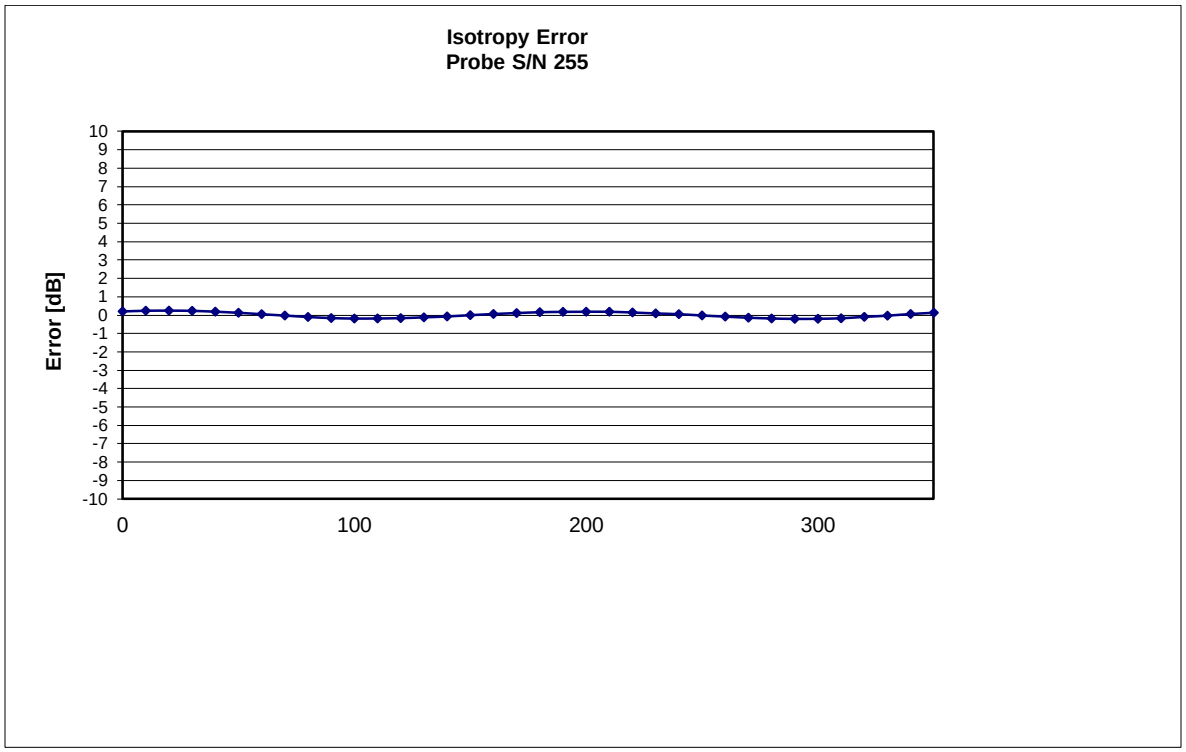
Uncertainty component	Tolerance (± %)	Probability distribution	Divisor	Standard uncertainty (± %)
Incident or forward power	2.5	R	√3	1.44
Reflected power	2	R	√3	1.15
Liquid conductivity measurement	1	R	√3	0.58
Liquid permittivity measurement	1	R	√3	0.58
Liquid conductivity deviation	1.5	R	√3	0.87
Liquid permittivity deviation	1.5	R	√3	0.87
Frequency deviation	2.25	R	√3	1.30
Field homogeneity	2.5	R	√3	1.44
Field-probe positioning	2.5	R	√3	1.44
Field-probe linearity	1.55	R	√3	0.89
Combined standard uncertainty		RSS		**3.50**

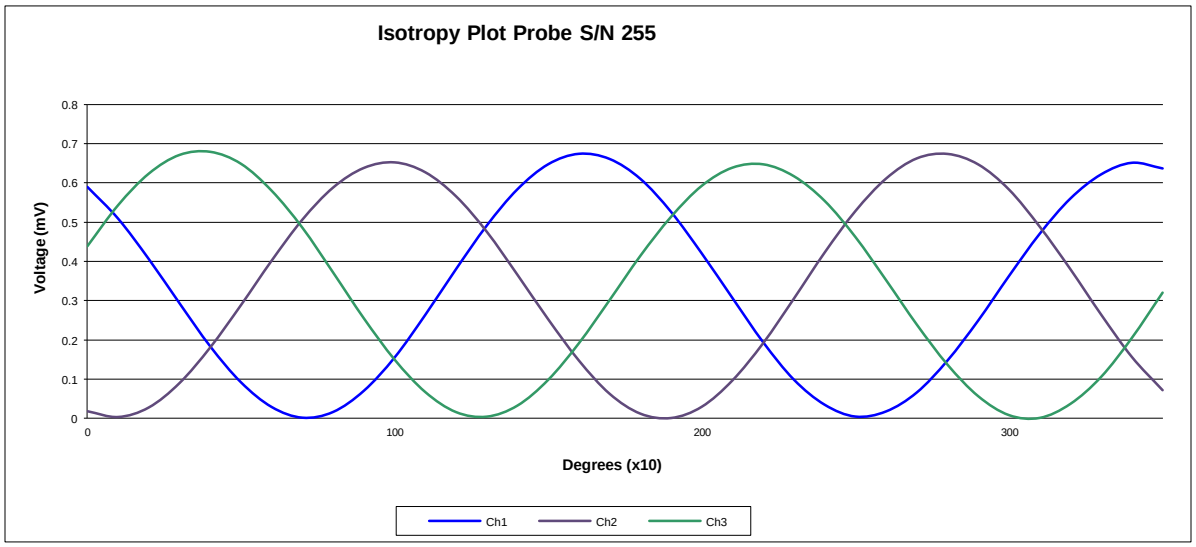
Project 5838
FCC ID: QQD-EC3331

Receiving Pattern Air

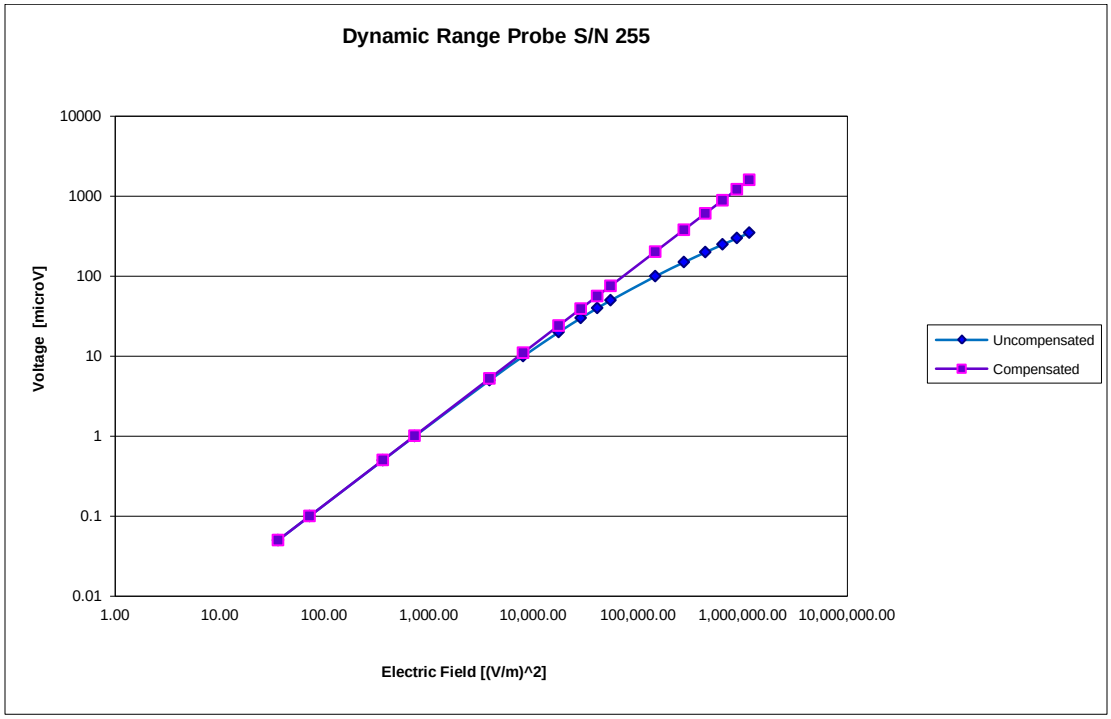


Isotropy Error Air





Dynamic Range



NCL CALIBRATION LABORATORIES

Calibration File No: DC-1729
Project Number: Kostec-D-cal-5832

C E R T I F I C A T E OF C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized Procedures and using transfer standards traceable to NRC/NIST.

Validation Dipole (Head&Body)

Manufacturer: APREL Laboratories
Part number: ALS-D-835-S-2
Frequency: 835 MHz
Serial No: 180-00554

Calibrated: 3rd November 2016
Released on: 3rd November 2016

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: _____

Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES

Suite 102, 303 Terry Fox Dr.
Kanata, ONTARIO
CANADA K2K 3J1

Division of APREL Lab.
TEL: (613) 435-8300
FAX: (613)435-8306

Conditions

Dipole 180-00554 was a re-calibration.

Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 21 °C +/- 0.5°C

Attestation

The below named signatories have conducted the calibration and review of the data which is presented in this calibration report.

We the undersigned attest that to the best of our knowledge the calibration of this subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.

Art Brennan, Quality Manager

Maryna Nesterova Calibration Engineer

Primary Measurement Standards

Instrument	Serial Number	Cal due date
Tektronix USB Power Meter	11C940	April 2, 2017
Network Analyzer Anritsu 37347C	002106	Feb. 4, 2017
Agilent Signal Generator	MY45094463	Dec. 11, 2017

Calibration Results Summary

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

Mechanical Dimensions

Length	Height
161.0 mm	89.8 mm

Tissue Validation

Tissue	Frequency	Dielectric constant, ε_r	Conductivity, σ [S/m]
Head	835 MHz	39.95	0.93
Body	835 MHz	55.46	1.00

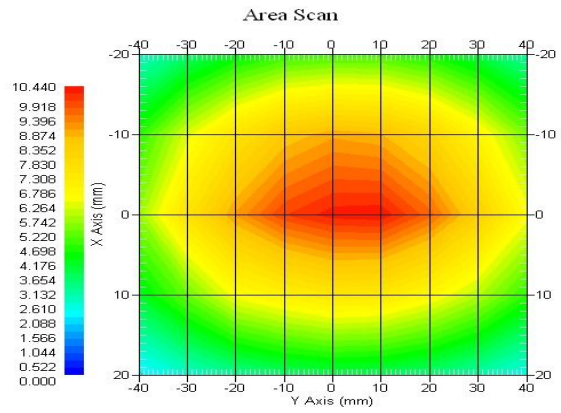
Electrical Specification

Tissue	Frequency	Return Loss	Impedance	SWR:
Head	835 MHz	-33.534 dB	49.689 Ω	1.046 U
Body	835 MHz	-22.838 dB	57.573 Ω	1.1206 U

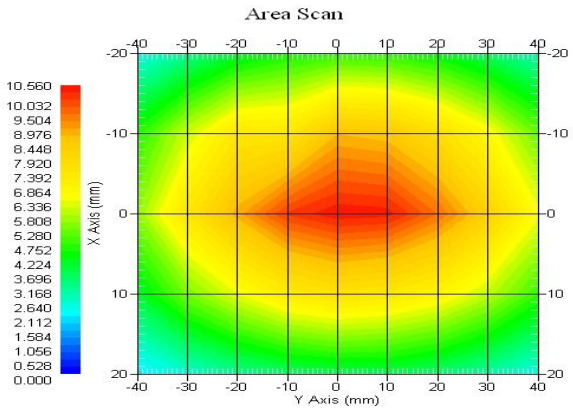
System Validation Results

Tissue	Frequency	1 Gram	10 Gram
Head	835 MHz	9.59	6.082
Body	835 MHz	9.76	6.27

Head



Body



Introduction

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole 180-00554. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the mechanical specifications. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALSAS-10U, along with APREL E-020 30 MHz to 6 GHz E-Field Probe Serial Number 225

References

- IEEE Standard 1528:2013
  IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- EN 62209-1:2006
  Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models. instrumentation, and procedures - Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices
- IEC 62209-2:2010
  Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
- D22-012-Tissue dielectric tissue calibration procedure
- D28-002-Dipole procedure for validation of SAR system using a dipole
- IEEE 1309 Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

Dipole Calibration uncertainty

The calibration uncertainty for the dipole is made up of various parameters presented below.

Mechanical	1%
Positioning Error	1.22%
Electrical	1.7%
Tissue	2.2%
Dipole Validation	2.2%
Combined Standard Uncertainty	**3.88% (7.76% K=2)**

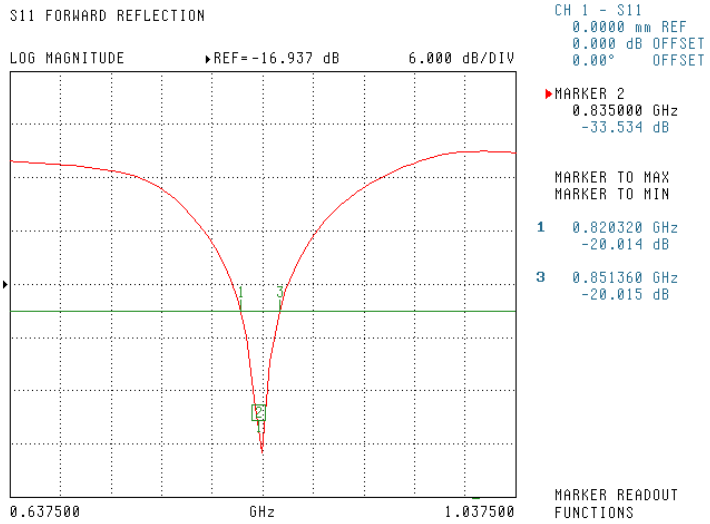
Electrical Calibration

Test	Results Head	Results Body
S11 R/L	-33.534 dB	-22.838 dB
Impedance	49.689 Ω	57.573 Ω
SWR	1.046 U	1.1206 U

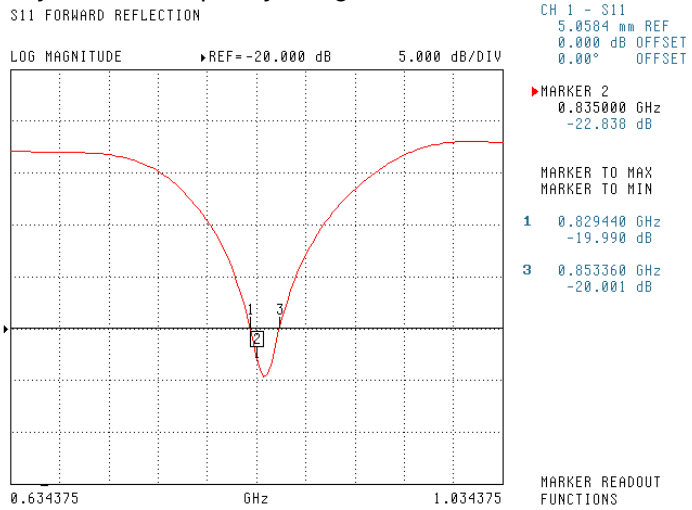
The Following Graphs are the results as displayed on the Vector Network Analyzer.

S11 Parameter Return Loss

Head Tissue: Frequency Range 820.32 MHz to 851.36 MHz

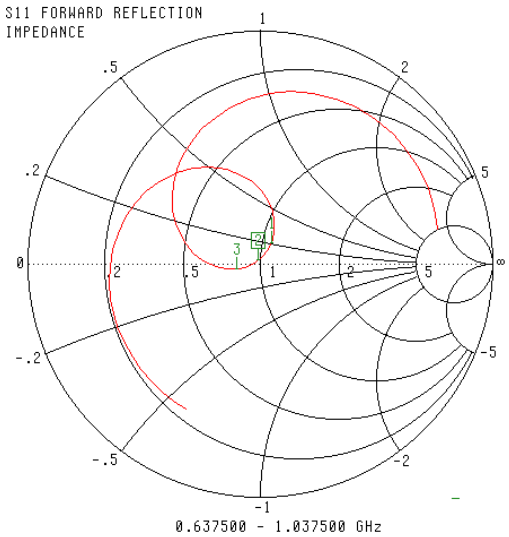


Body Tissue: Frequency Range 0.829 to 0.853 GHz



Smith Chart Dipole Impedance

Head Tissue



CH 1 - S11
0.0000 mm REF
0.000 dB OFFSET
0.00° OFFSET

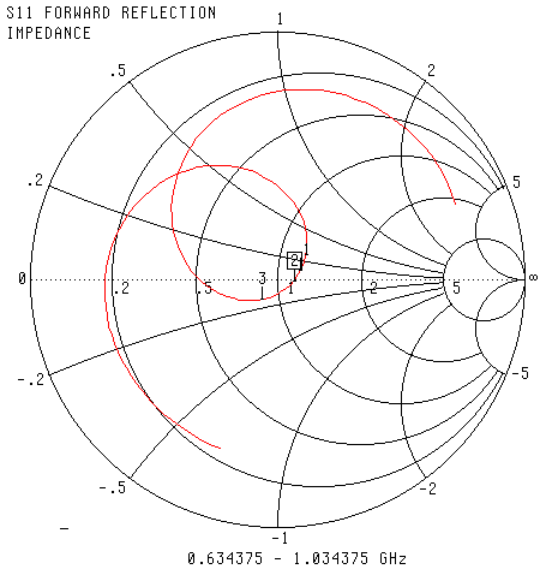
▶MARKER 2
0.835000 GHz
49.689 Ω
1.318 jΩ

MARKER TO MAX
MARKER TO MIN

1 0.820320 GHz
54.624 Ω
9.613 jΩ
3 0.851360 GHz
41.042 Ω
-2.063 jΩ

MARKER READOUT
FUNCTIONS

Body Tissue



CH 1 - S11
5.0584 mm REF
0.000 dB OFFSET
0.00° OFFSET

▶MARKER 2
0.835000 GHz
57.573 Ω
-913.825 jmΩ

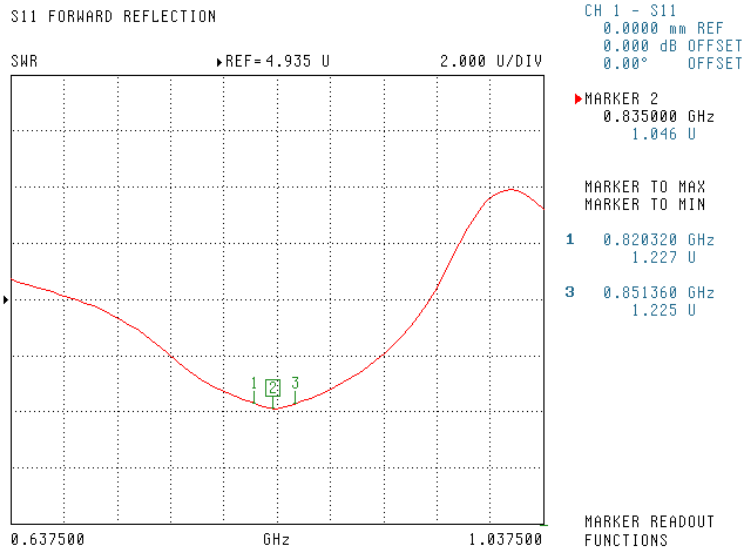
MARKER TO MAX
MARKER TO MIN

1 0.829440 GHz
60.450 Ω
3.856 jΩ
3 0.853360 GHz
44.122 Ω
-7.473 jΩ

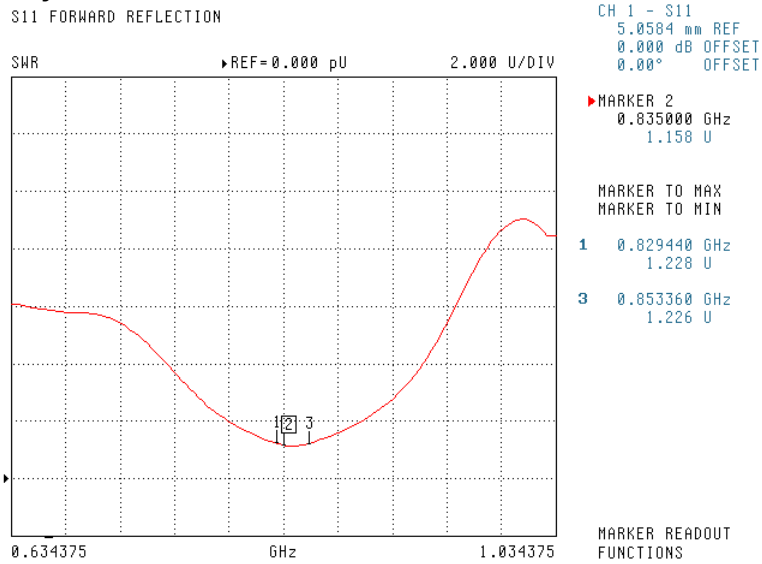
MARKER READOUT
FUNCTIONS

SWR

Head Tissue



Body Tissue



Project 5838
FCC ID: QQD-EC3331

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1730

C E R T I F I C A T E OF C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

Validation Dipole (Head)

Manufacturer: APREL Laboratories
Part number: ALS-D-900-S-2
Frequency: 900 MHz
Serial No: 190-00604

Calibrated: 3rd November 2016
Released on: 3rd November 2016

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: 

Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES

Suite 102, 303 Terry Fox Dr.
Kanata, ONTARIO
CANADA K2K 3J1

Division of APREL Lab.
TEL: (613) 435-8300
FAX: (613)435-8306

Conditions

Dipole 190-00604 was a re-calibration.

Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 21 °C +/- 0.5°C

Attestation

The below named signatories have conducted the calibration and review of the data which is presented in this calibration report.

We the undersigned attest that to the best of our knowledge the calibration of this subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.

Art Brennan, Quality Manager

Maryna Nesterova Calibration Engineer

Primary Measurement Standards

Instrument	Serial Number	Cal due date
Tektronix USB Power Meter	11C940	April 2, 2017
Network Analyzer Anritsu 37347C	002106	Feb 4, 2017
Agilent Signal Generator	MY45094463	Dec. 11, 2017

Calibration Results Summary

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

Mechanical Dimensions

Length	Height
149 mm	83.3 mm

Tissue Validation

Tissue	Frequency	Dielectric constant, ε_r	Conductivity, σ [S/m]
Head	900 MHz	39.54	1.00
Body	900 MHz	55.62	1.05

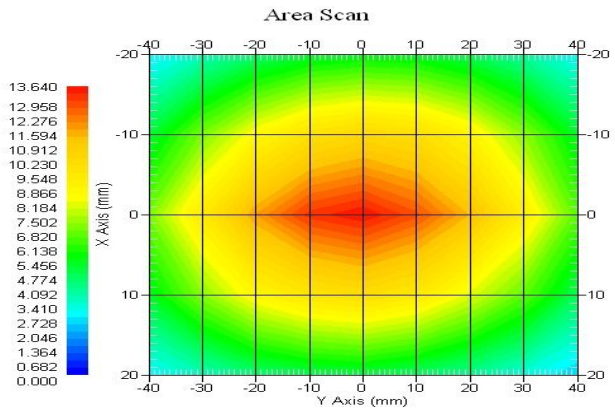
Electrical Specification

Tissue	Frequency	Return Loss	Impedance	SWR
Head	900 MHz	-29.821 dB	48.789 Ω	1.067 U
Body	900 MHz	-24.34 dB	48.663 Ω	1.132 U

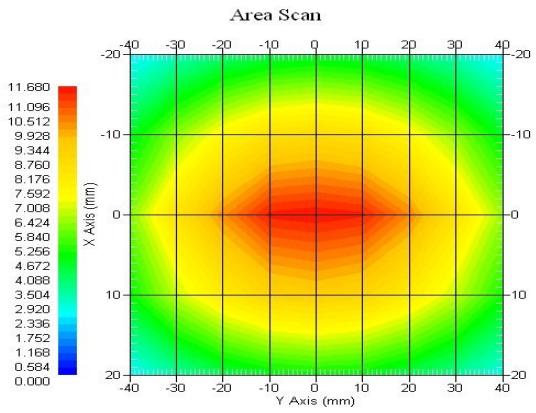
System Validation Results

Tissue	Frequency	1 Gram	10 Gram
Head	900 MHz	11.266	7.069
Body	900MHz	11.072	7.07

Head



Body



Introduction

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole 190-00614. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the mechanical specifications. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALSAS-10U, along with APREL E-020 30 MHz to 6 GHz E-Field Probe Serial Number 225.

References

- IEEE Standard 1528:2013
  IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- EN 62209-1:2006
  Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models. instrumentation, and procedures - Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices
- IEC 62209-2:2010
  Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
- D22-012-Tissue dielectric tissue calibration procedure
- D28-002-Dipole procedure for validation of SAR system using a dipole
- IEEE 1309 Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

Dipole Calibration uncertainty

The calibration uncertainty for the dipole is made up of various parameters presented below.

Mechanical	1%
Positioning Error	1.22%
Electrical	1.7%
Tissue	2.2%
Dipole Validation	2.2%
Combined Standard Uncertainty	**3.88% (7.76% K=2)**

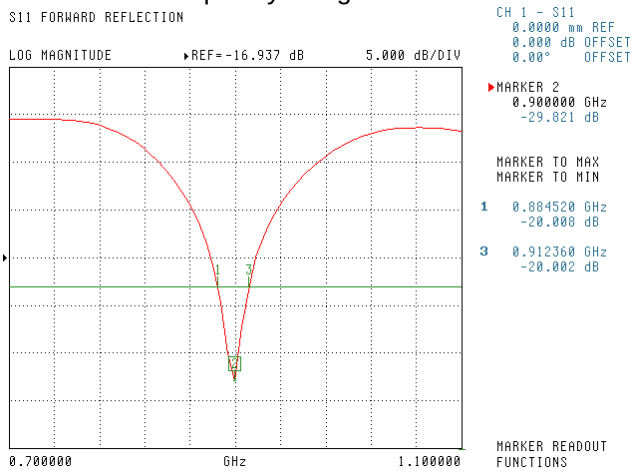
Electrical Calibration

Test	Results Head	Results Body
S11 R/L	-29.821 dB	-24.34 dB
Impedance	48.789 Ω	48.663 Ω
SWR	1.067 U	1.132 U

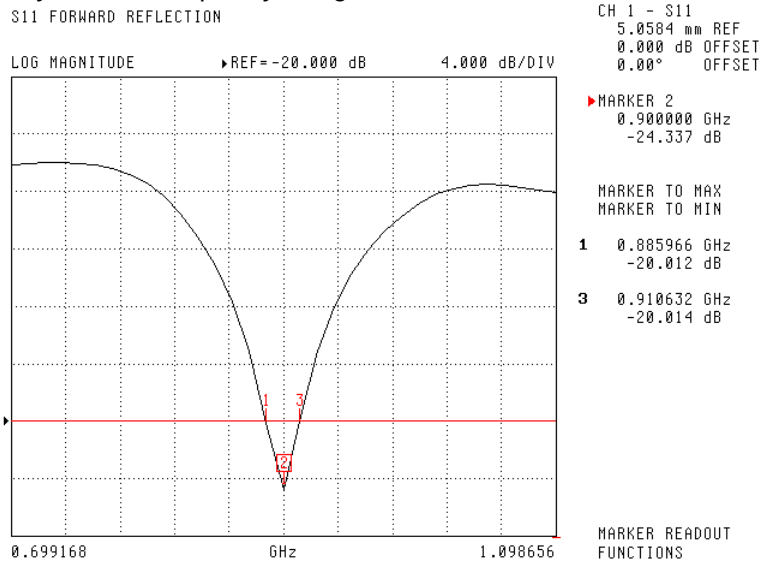
The Following Graphs are the results as displayed on the Vector Network Analyzer.

S11 Parameter Return Loss

Head Tissue: Frequency Range 884.52 MHz to 912.36 MHz



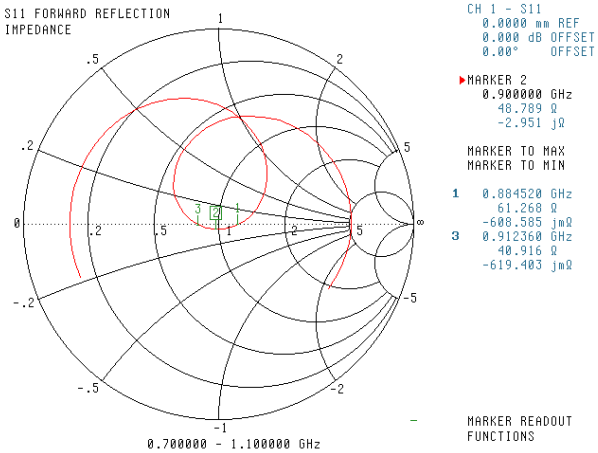
Body Tissue: Frequency Range 0.886 to 0.911 GHz



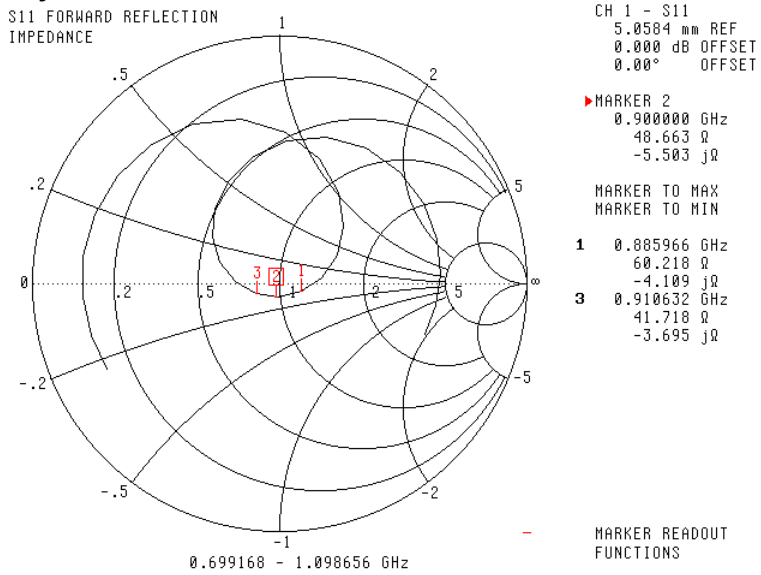
Project 5838
FCC ID: QQD-EC3331

Smith Chart Dipole Impedance

Head Tissue

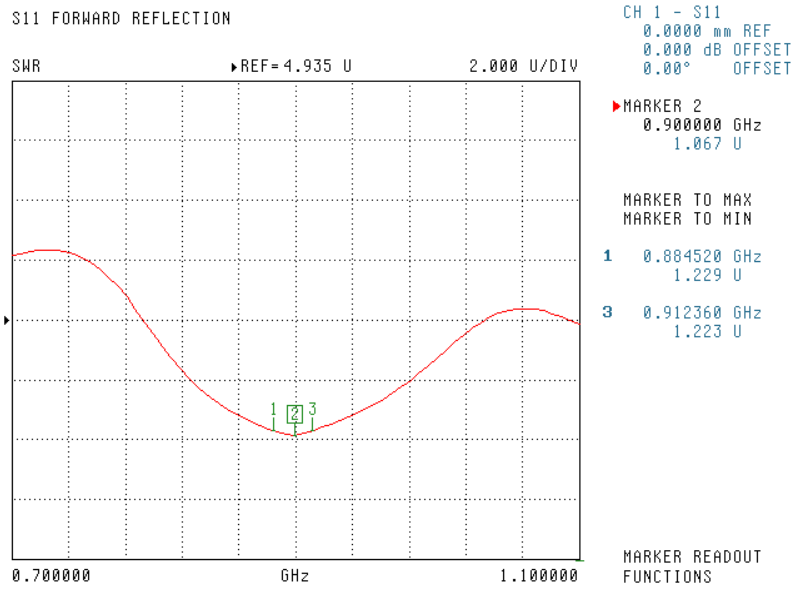


Body Tissue

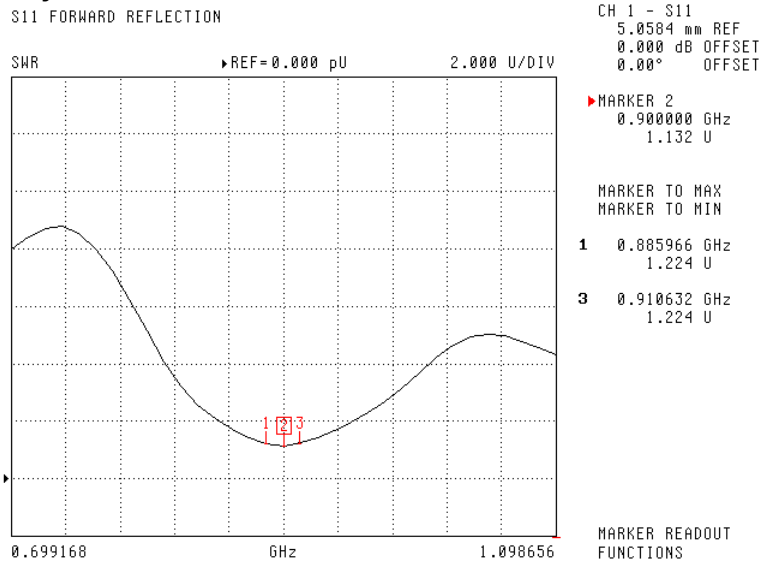


SWR

Head Tissue



Body Tissue



Project 5838
FCC ID: QQD-EC3331

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1731

C E R T I F I C A T E OF C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

Validation Dipole (Head & Body)

Manufacturer: APREL Laboratories
Part number: ALS-D-1800-S-2
Frequency: 1800 MHz
Serial No: 200-00654

Calibrated: 3rd November 2016
Released on: 3rd November 2016

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: _____

Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES
Suite 102, 303 Terry Fox Dr.
Kanata, ONTARIO
CANADA K2K 3J1
Division of APREL Lab.
TEL: (613) 435-8300
FAX: (613)435-8306

Conditions

Dipole 200-00654 was a re-calibration.

Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 21 °C +/- 0.5°C

Attestation

The below named signatories have conducted the calibration and review of the data which is presented in this calibration report.

We the undersigned attest that to the best of our knowledge the calibration of this subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.

Art Brennan, Quality Manager

Maryna Nesterova Calibration Engineer

Primary Measurement Standards

Instrument	Serial Number	Cal due date
Tektronix USB Power Meter	11C940	April 2, 2017
Network Analyzer Anritsu 37347C	002106	Feb.4, 2017
Agilent Signal Generator	MY45094463	Dec. 11, 2017

Calibration Results Summary

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

Mechanical Dimensions

Length	Height
72.0 mm	41.7 mm

Tissue Validation

Tissue	Frequency	Dielectric constant, ε_r	Conductivity, σ [S/m]
Head	1800 MHz	38.97	1.39
Body	1800 MHz	39.48	1.41

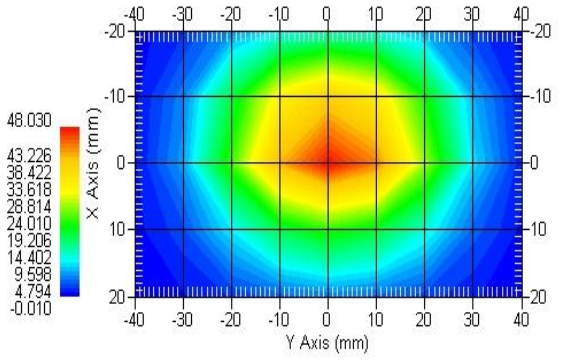
Electrical Specification

Tissue	Frequency	Return Loss	Impedance	SWR
Head	1800 MHz	-28.266 dB	50.524 Ω	1.080 U
Body	1800 MHz	-28.202 dB	51.522 Ω	1.081 U

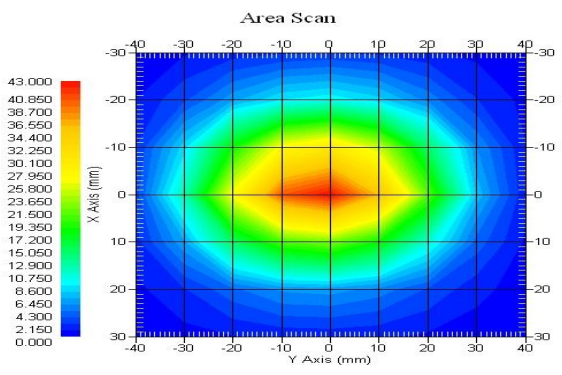
System Validation Results

Tissue	Frequency	1 Gram	10 Gram
Head	1800 MHz	37.61	19.56
Body	1800 MHz	38.83	19.56

Head



Body



Introduction

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole 200-00654. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the mechanical specifications. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALSAS-10U, along with APREL E-020 30 MHz to 6 GHz E-Field Probe Serial Number 225.

References

- IEEE Standard 1528:2013
  IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- EN 62209-1:2006
  Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models. instrumentation, and procedures - Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices
- IEC 62209-2:2010
  Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
- D22-012-Tissue dielectric tissue calibration procedure
- D28-002-Dipole procedure for validation of SAR system using a dipole
- IEEE 1309 Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

Dipole Calibration uncertainty

The calibration uncertainty for the dipole is made up of various parameters presented below.

Mechanical	1%
Positioning Error	1.22%
Electrical	1.7%
Tissue	2.2%
Dipole Validation	2.2%
Combined Standard Uncertainty	**3.88% (7.76% K=2)**

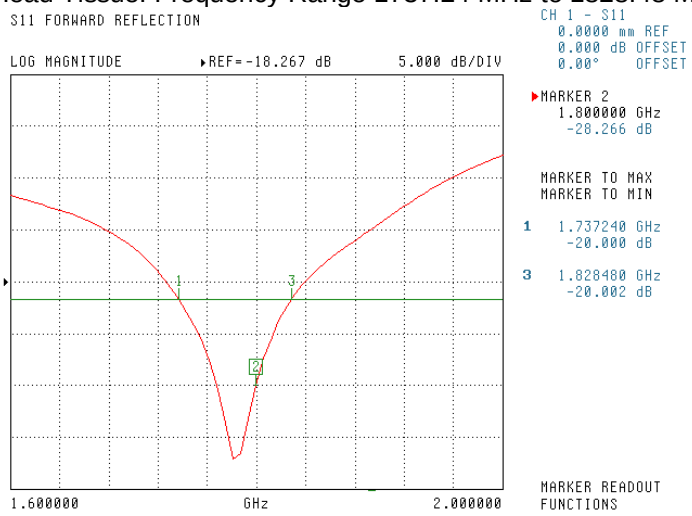
Electrical Calibration

Test	Result Head
S11 R/L	-28.202 dB
Impedance	51.522 Ω
SWR	1.081 U

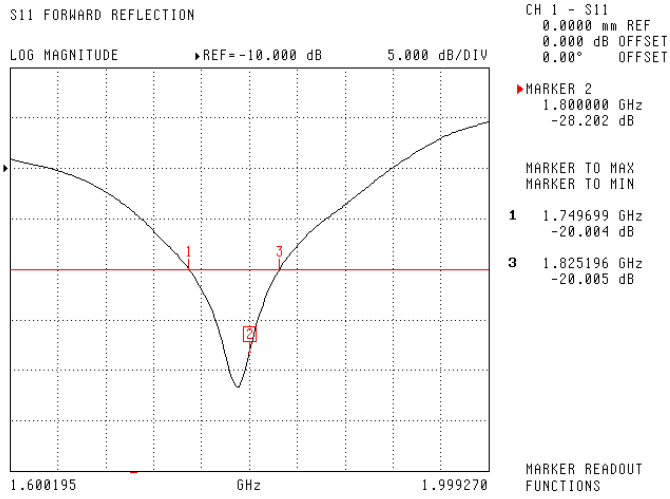
The Following Graphs are the results as displayed on the Vector Network Analyzer.

S11 Parameter Return Loss

Head Tissue: Frequency Range 1737.24 MHz to 1828.48 MHz

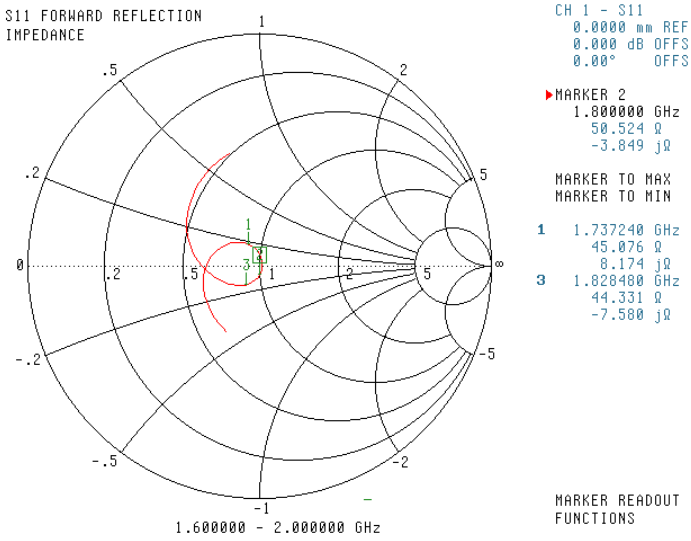


Body Tissue: Frequency Range 1749.70 MHz to 1825.19 MHz

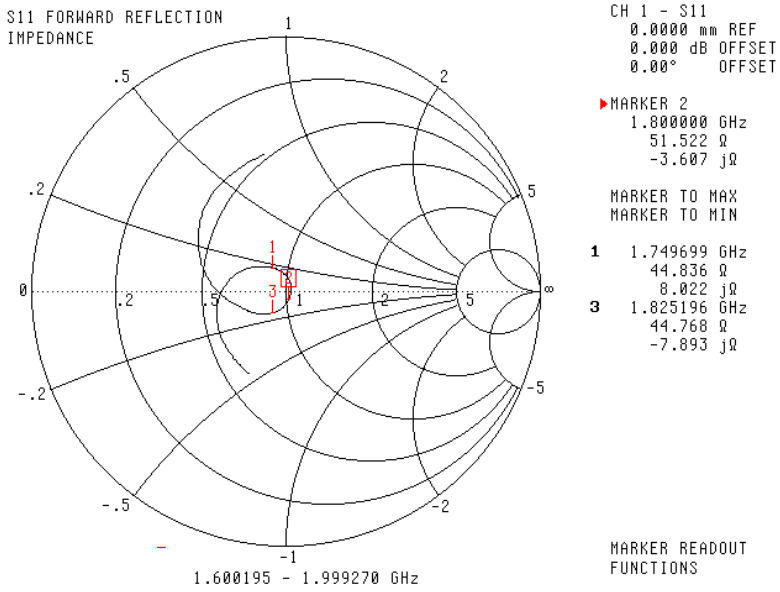


Smith Chart Dipole Impedance

Head

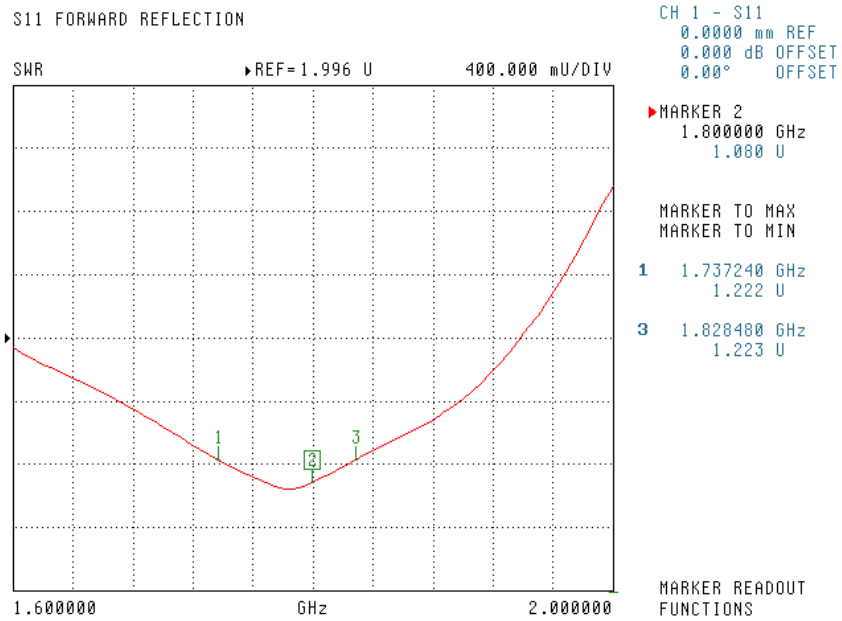


Body

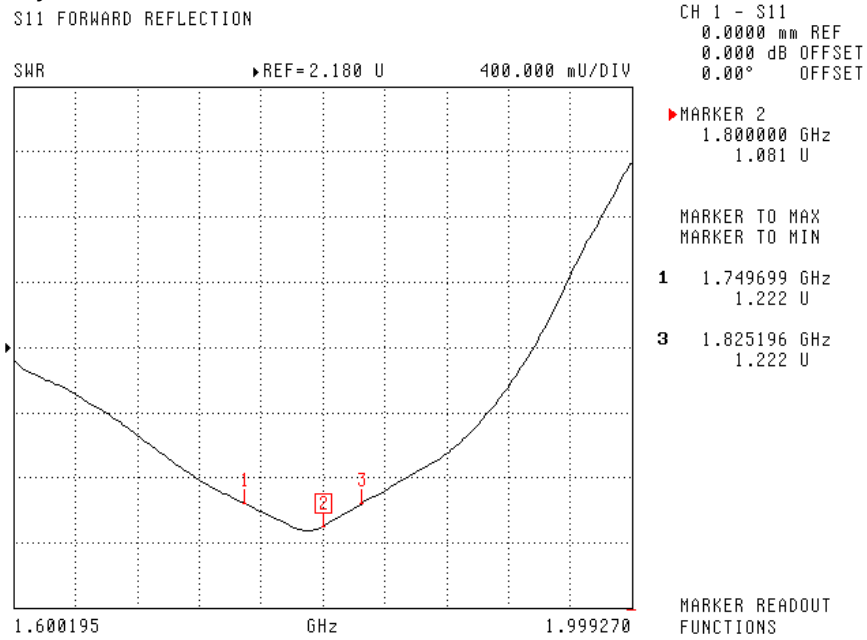


SWR

Head



Body



Project 5838
FCC ID: QQD-EC3331

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1732

C E R T I F I C A T E OF C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

Validation Dipole (Head & Body)

Manufacturer: APREL Laboratories
Part number: ALS-D-1900-S-2
Frequency: 1900 MHz
Serial No: 210-00704

Calibrated: 3rd November 2016
Released on: 3rd November 2016

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: _____

Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES

Suite 102, 303 Terry Fox Dr.
Kanata, ONTARIO
CANADA K2K 3J1

Division of APREL Lab.
TEL: (613) 435-8300
FAX: (613)435-8306

Conditions

Dipole 210-00704 was a re-calibration.

Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 21 °C +/- 0.5°C

Attestation

The below named signatories have conducted the calibration and review of the data which is presented in this calibration report.

We the undersigned attest that to the best of our knowledge the calibration of this subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.

Art Brennan, Quality Manager

Maryna Nesterova Calibration Engineer

Primary Measurement Standards

Instrument	Serial Number	Cal due date
Tektronix USB Power Meter	11C940	April 2, 2017
Network Analyzer Anritsu 37347C	002106	Feb. 4, 2017
Agilent Signal Generator	MY45094463	Dec. 11, 2017

Calibration Results Summary

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

Mechanical Dimensions

Length	Height
68 mm	39.5 mm

Tissue Validation

Tissue	Frequency	Dielectric constant, ε_r	Conductivity, σ [S/m]
Head	1900 MHz	40.20	1.38
Body	1900 MHz	52.63	1.46

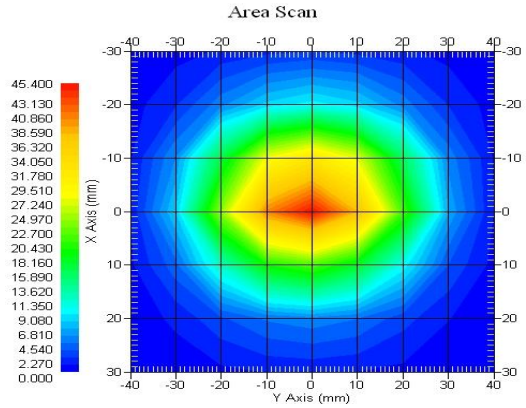
Electrical Specification

Tissue	Frequency	SWR:	Return Loss	Impedance
Head	1900 MHz	1.098 U	-26.603 dB	48.996 Ω
Body	1900 MHz	1.153 U	-22.963 dB	52.196 Ω

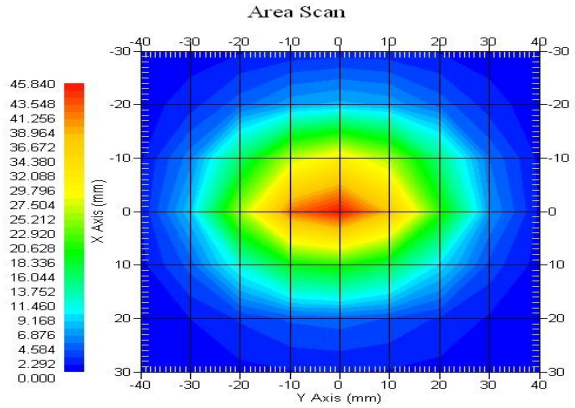
System Validation Results

Tissue	Frequency	1 Gram	10 Gram
Head	1900 MHz	40.4	20.43
Body	1900 MHz	40.51	20.3

Head



Body



Introduction

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole 210-00704. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the mechanical specifications. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALSAS-10U, along with APREL E-020 30 MHz to 6 GHz E-Field Probe Serial Number 225.

References

- IEEE Standard 1528:2013
  IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- EN 62209-1:2006
  Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models. instrumentation, and procedures - Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices
- IEC 62209-2:2010
  Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
- D22-012-Tissue dielectric tissue calibration procedure
- D28-002-Dipole procedure for validation of SAR system using a dipole
- IEEE 1309 Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

Dipole Calibration uncertainty

The calibration uncertainty for the dipole is made up of various parameters presented below.

Mechanical	1%
Positioning Error	1.22%
Electrical	1.7%
Tissue	2.2%
Dipole Validation	2.2%
Combined Standard Uncertainty	**3.88% (7.76% K=2)**

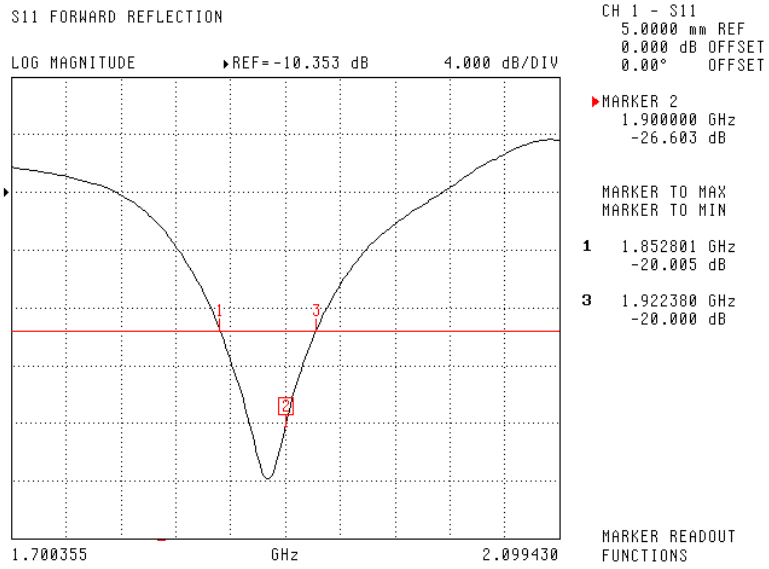
Electrical Calibration

Test	Results Head	Results Body
S11 R/L	-26.603 dB	-22.963 dB
Impedance	48.996 Ω	52.196 Ω
SWR	1.098 U	1.153 U

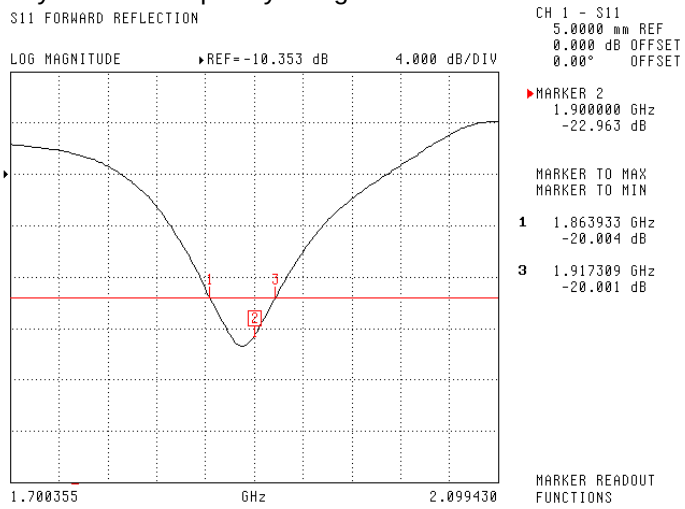
The Following Graphs are the results as displayed on the Vector Network Analyzer.

S11 Parameter Return Loss

Head Tissue: Frequency Range 1852.8 MHz to 1922.3 MHz

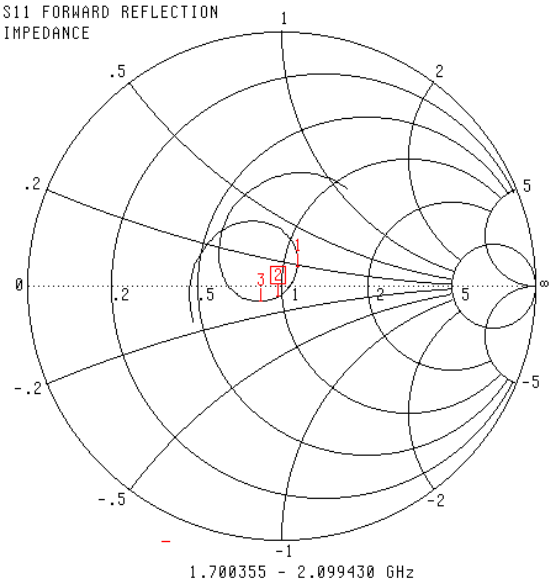


Body Tissue: Frequency Range 18643.9 MHz to 1917.3 MHz



Smith Chart Dipole Impedance

Head



CH 1 - S11
5.0000 mm REF
0.000 dB OFFSET
0.00° OFFSET

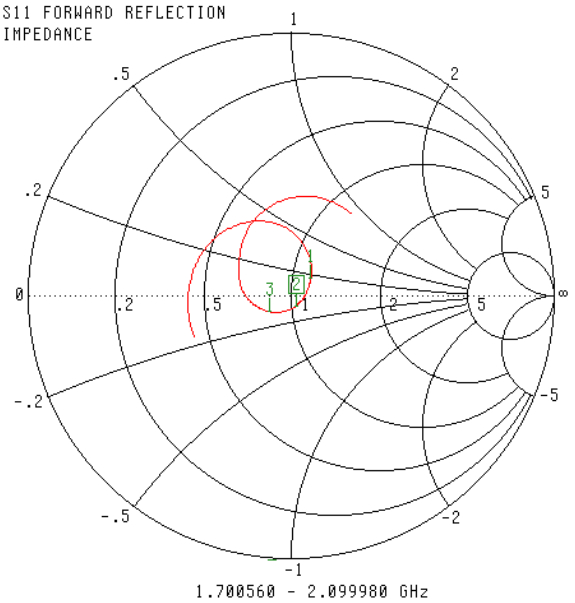
▶MARKER 2
1.900000 GHz
48.996 Ω
-4.489 jΩ

MARKER TO MAX
MARKER TO MIN

1 1.852801 GHz
56.555 Ω
8.499 jΩ
3 1.922380 GHz
42.565 Ω
-5.488 jΩ

MARKER READOUT
FUNCTIONS

Body



CH 1 - S11
5.0584 mm REF
0.000 dB OFFSET
0.00° OFFSET

▶MARKER 2
1.900000 GHz
52.196 Ω
-4.405 jΩ

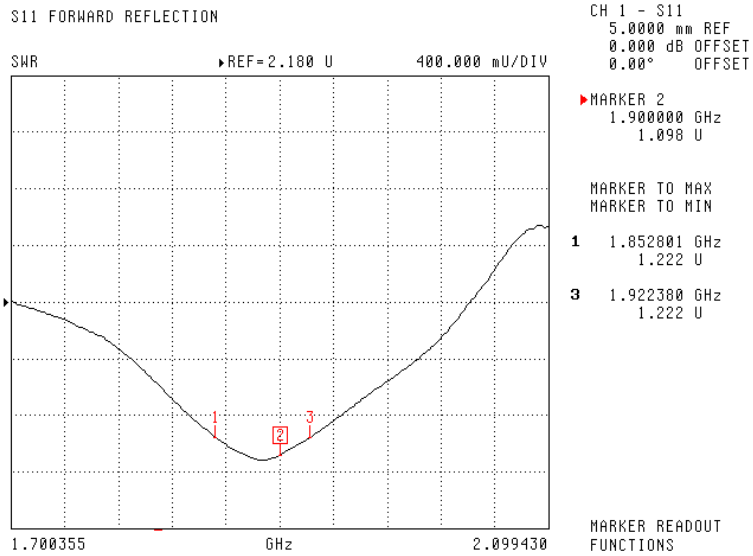
MARKER TO MAX
MARKER TO MIN

1 1.860470 GHz
58.140 Ω
7.135 jΩ
3 1.932204 GHz
42.555 Ω
-5.598 jΩ

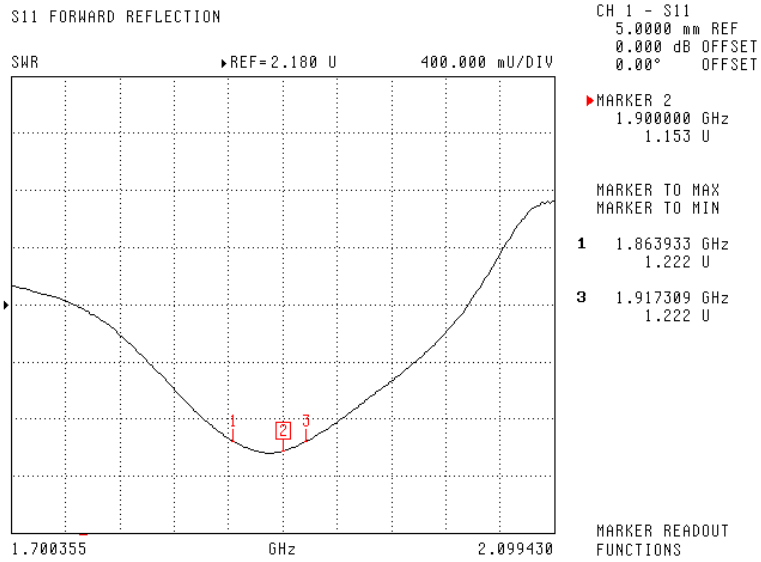
MARKER READOUT
FUNCTIONS

SWR

Head



Body



Project 5838
FCC ID: QQD-EC3331

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1734

C E R T I F I C A T E OF C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

Validation Dipole (Body)

Manufacturer: APREL Laboratories
Part number: ALS-D-2100-S-2
Frequency: 2100 MHz
Serial No: 217-00802

Calibrated: 2nd November 2016
Released on: 2nd November 2016

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: _____

Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES
Suite 102, 303 Terry Fox Dr.
Kanata, ONTARIO
CANADA K2K 3J1
Division of APREL Lab.
TEL: (613) 435-8300
FAX: (613)435-8306

Conditions

Dipole 217-00802 was a re-calibration.

Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 21 °C +/- 0.5°C

Attestation

The below named signatories have conducted the calibration and review of the data which is presented in this calibration report.

We the undersigned attest that to the best of our knowledge the calibration of this subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.

Art Brennan, Quality Manager

Maryna Nesterova Calibration Engineer

Primary Measurement Standards

Instrument	Serial Number	Cal due date
Tektronix USB Power Meter	11C940	April 2, 2017
Network Analyzer Anritsu 37347C	002106	Feb. 4, 2017
Agilent Signal Generator	MY45094463	Dec. 11, 2017

Calibration Results Summary

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

Mechanical Dimensions

Length	Height
64.5 mm	37.5 mm

Tissue Validation

Tissue	Frequency	Dielectric constant, ε_r	Conductivity, σ [S/m]
Body	2100 MHz	53.61	1.90

Electrical Specification

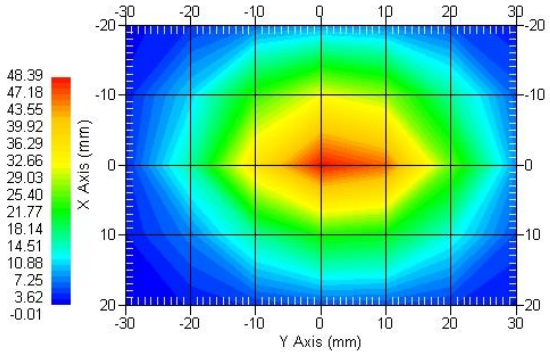
Tissue	Frequency	SWR:	Return Loss	Impedance
Body	2210 MHz	1.105 U	- 26.027dB	45.253 Ω

System Validation Results

Tissue	Frequency	1 Gram	10 Gram
Body	2100 MHz	41.6 W/kg	19.7 W/kg

Body

Area Scan



Introduction

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole 217-00802. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the mechanical specifications. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALSAS-10U, along with APREL E-020 30 MHz to 6 GHz E-Field Probe Serial Number 225.

References

- IEEE Standard 1528:2013
  IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- EN 62209-1:2006
  Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models. instrumentation, and procedures - Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices
- IEC 62209-2:2010
  Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
- D22-012-Tissue dielectric tissue calibration procedure
- D28-002-Dipole procedure for validation of SAR system using a dipole
- IEEE 1309 Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

Dipole Calibration uncertainty

The calibration uncertainty for the dipole is made up of various parameters presented below.

Mechanical	1%
Positioning Error	1.22%
Electrical	1.7%
Tissue	2.2%
Dipole Validation	2.2%
Combined Standard Uncertainty	**3.88% (7.76% K=2)**

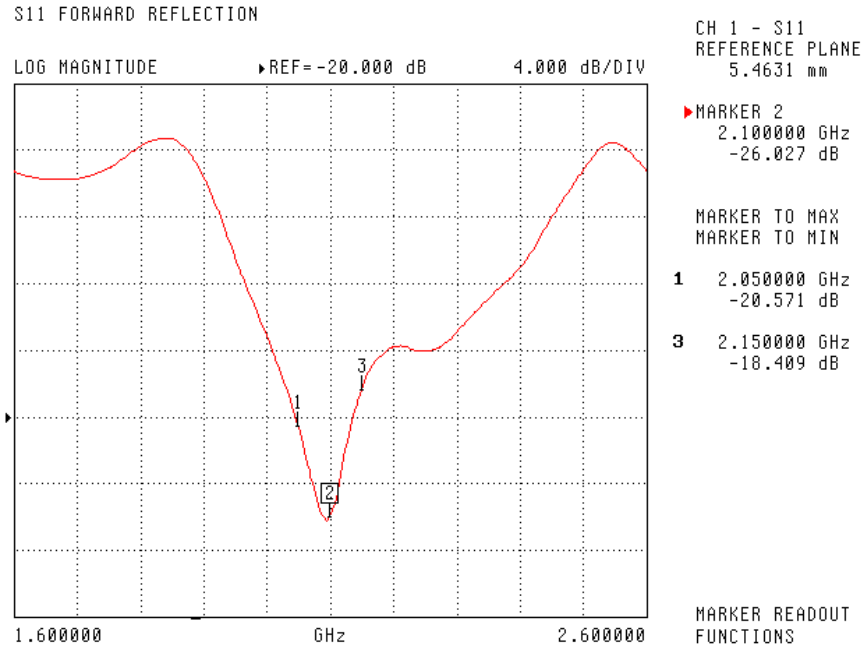
Electrical Calibration

Test	Results Body
S11 R/L	- 26.027dB
Impedance	45.253 Ω
SWR	1.105 U

The Following Graphs are the results as displayed on the Vector Network Analyzer.

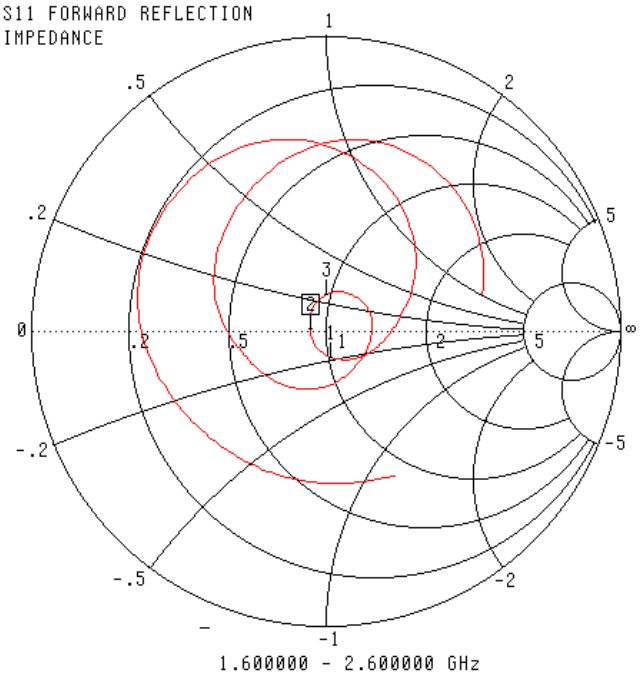
S11 Parameter Return Loss

Body Tissue: Frequency Range 2050 to 2012 MHz



Smith Chart Dipole Impedance

Body



CH 1 - S11
REFERENCE PLANE
5.4631 mm

▶MARKER 2
2.100000 GHz
45.253 Ω
336.760 jmΩ

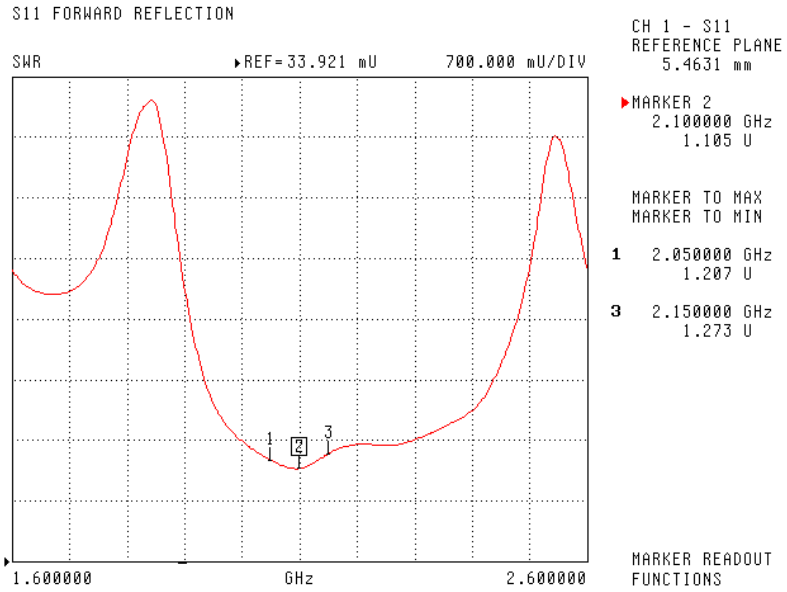
MARKER TO MAX
MARKER TO MIN

1 2.050000 GHz
50.990 Ω
-9.446 jΩ
3 2.150000 GHz
49.053 Ω
11.945 jΩ

MARKER READOUT
FUNCTIONS

SWR

Body



Project 5838
FCC ID: QQD-EC3331

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1733

C E R T I F I C A T E OF C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

Validation Dipole (Head&Body)

Manufacturer: APREL Laboratories
Part number: ALS-D-2450-S-2
Frequency: 2450 MHz
Serial No: 220-00756

Calibrated: 2nd November 2016
Released on: 2nd November 2016

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: _____

Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES
Suite 102, 303 Terry Fox Dr.
Kanata, ONTARIO
CANADA K2K 3J1
Division of APREL Lab.
TEL: (613) 435-8300
FAX: (613)435-8306

Conditions

Dipole 220-00756 was a re-calibration.

Ambient Temperature of the Laboratory:	22 °C +/- 0.5°C
Temperature of the Tissue:	21 °C +/- 0.5°C

Attestation

The below named signatories have conducted the calibration and review of the data which is presented in this calibration report.

We the undersigned attest that to the best of our knowledge the calibration of this subject has been accurately conducted and that all information contained within the results pages have been reviewed for accuracy.

Art Brennan, Quality Manager

Maryna Nesterova Calibration Engineer

Primary Measurement Standards

Instrument	**Serial Number**	**Cal due date**
Tektronix USB Power Meter	11C940	April 2, 2017
Network Analyzer Anritsu 37347C	002106	Feb. 4, 2017
Agilent Signal Generator	MY45094463	Dec. 11, 2017

Calibration Results Summary

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

Mechanical Dimensions

Length	Height
51.5 mm	30.4 mm

Tissue Validation

Tissue	Frequency	Dielectric constant, ε_r	Conductivity, σ [S/m]
Head	2450 MHz	32.26	1.84
Body	2450 MHz	53.61	1.90

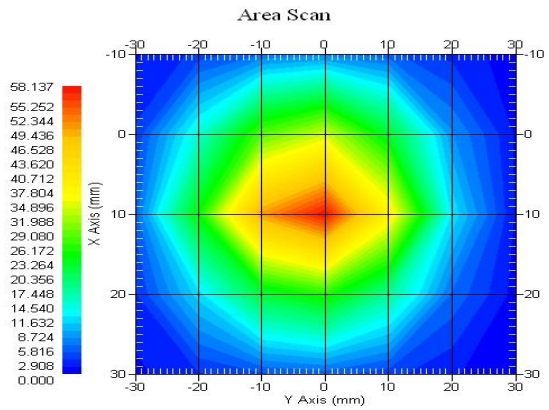
Electrical Specification

Tissue	Frequency	SWR:	Return Loss	Impedance
Head	2450 MHz	1.017 U	-31.001 dB	50.459 Ω
Body	2450 MHz	1.079 U	-28.376 dB	51.169 Ω

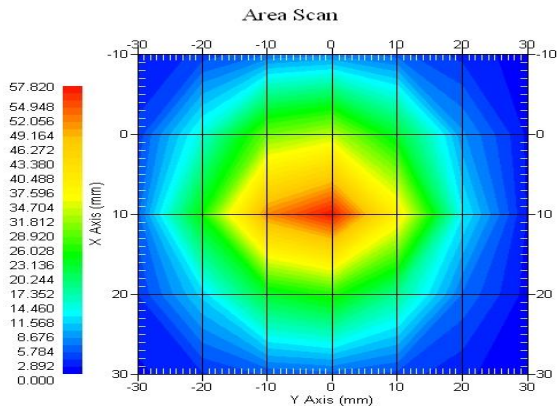
System Validation Results

Tissue	Frequency	1 Gram	10 Gram
Head	2450 MHz	54.916	25.327
Body	2450 MHz	52.418	24.691

Head



Body



Introduction

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole 220-00756. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the mechanical specifications. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALSAS-10U, along with APREL E-020 30 MHz to 6 GHz E-Field Probe Serial Number 225.

References

- IEEE Standard 1528:2013
  IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
- EN 62209-1:2006
  Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models. instrumentation, and procedures - Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices
- IEC 62209-2:2010
  Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
- D22-012-Tissue dielectric tissue calibration procedure
- D28-002-Dipole procedure for validation of SAR system using a dipole
- IEEE 1309 Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

Dipole Calibration uncertainty

The calibration uncertainty for the dipole is made up of various parameters presented below.

Mechanical	1%
Positioning Error	1.22%
Electrical	1.7%
Tissue	2.2%
Dipole Validation	2.2%
Combined Standard Uncertainty	**3.88% (7.76% K=2)**

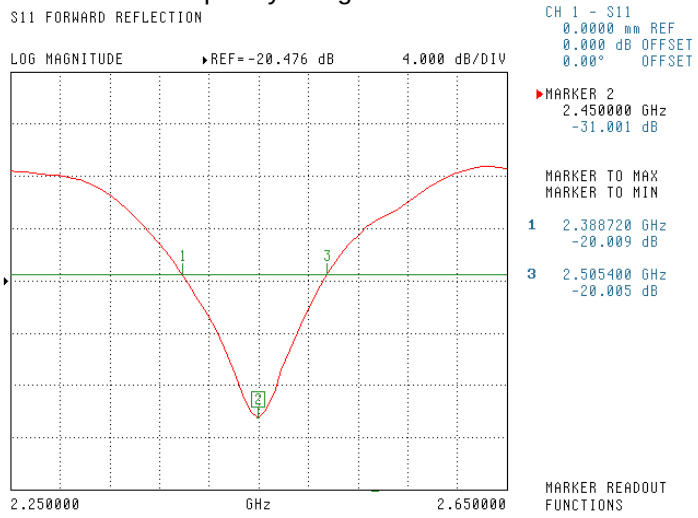
Electrical Calibration

Test	Results Head	Results Body
S11 R/L	-31.001 dB	-28.376 dB
Impedance	50.459 Ω	51.169 Ω
SWR	1.017 U	1.079 U

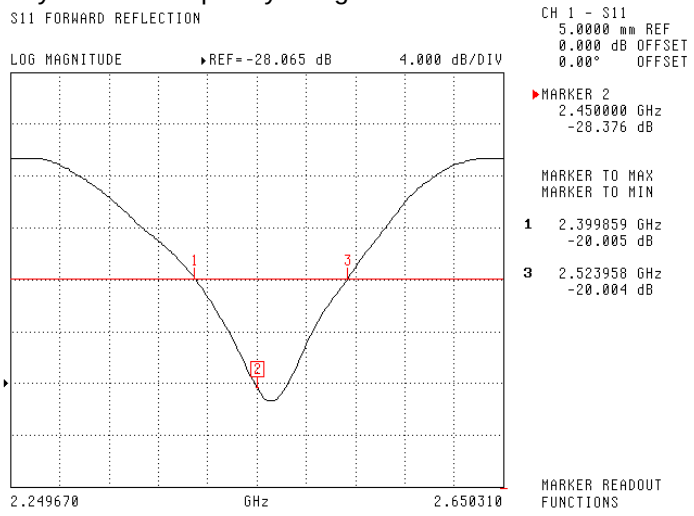
The Following Graphs are the results as displayed on the Vector Network Analyzer.

S11 Parameter Return Loss

Head Tissue: Frequency Range 2388.72 MHz to 2505.40 MHz



Body Tissue: Frequency Range 2399.8 to 2523.9 MHz



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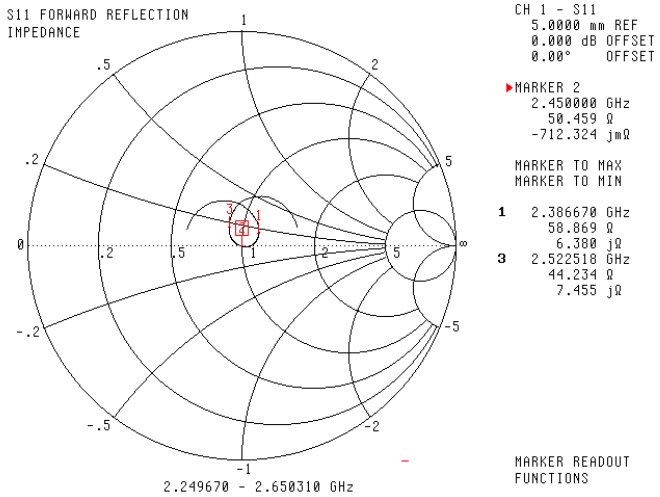
Smith Chart Dipole Impedance

Head



CH 1 - S11
5.0000 mm REF
0.000 dB OFFSET
0.00° OFFSET

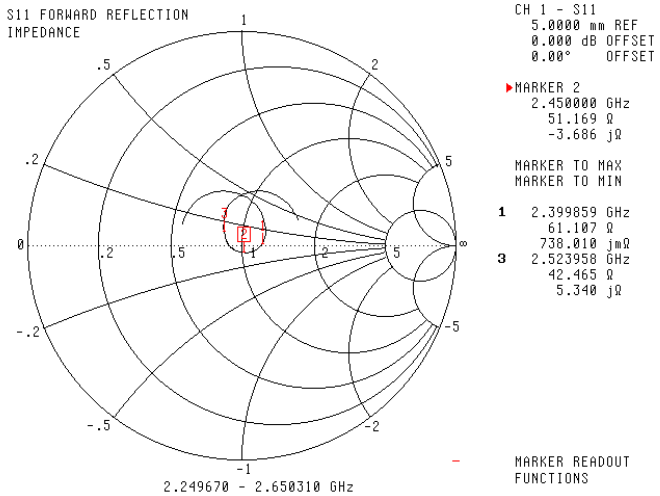
MARKER 2
2.450000 GHz
50.459 Ω
-712.324 jΩ

MARKER TO MAX
MARKER TO MIN

1 2.386670 GHz
58.869 Ω
6.380 jΩ
3 2.522518 GHz
44.234 Ω
7.455 jΩ

MARKER READOUT
FUNCTIONS

Body



CH 1 - S11
5.0000 mm REF
0.000 dB OFFSET
0.00° OFFSET

MARKER 2
2.450000 GHz
51.169 Ω
-3.686 jΩ

MARKER TO MAX
MARKER TO MIN

1 2.399859 GHz
61.107 Ω
738.010 jΩ
3 2.523958 GHz
42.465 Ω
5.340 jΩ

MARKER READOUT
FUNCTIONS

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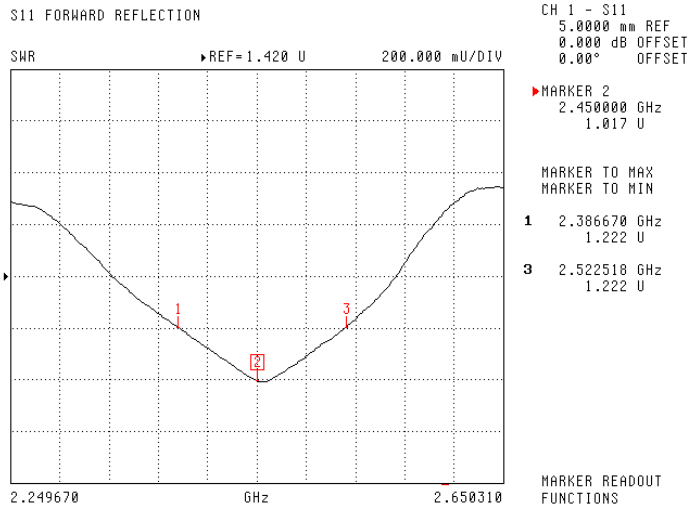
SWR

Head



Body