FCC SAR TEST REPORT

KOSTEC Co., Ltd. 28(175-20, Annyeong-dong) 406-gil sejaro, Hwaseong-si, Gyeonggi-do, Korea Tel:031-222-4251, Fax:031-222-4252	Report No: KST-FCS-170003	KOSTEC Co., Ltd. http://www.kostec.org

1. Applicant

   • Name : Midland Radio Corporation

   • Address : 5900 Parretta Drive, Kansas City, Missouri United States 6412

2. Test Item

   • Product Name: GMRS / FRS

   • Model Name : XT511A

   • Brand Name: -

3. Manufacturer

   • Name : Global Link Corporation Ltd.

   • Address : 21/F Kolling Centre, 77-79 Granville Road, Tsim Sha Tsui Kowloon, Hong Kong

4. Date of Test : 2017. 06. 29.

5. Test Method Used : FCC 47 CFR Parts 2
   KDB 447498 D01 v06
   KDB 865664 D01 v01r04

6. Test Result : Compliance

7. Note: -

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.

Affirmation	Tested by Name : Kong, Hyeri (Signature)	Technical Manager Name : Park, Gyeong-Hyeon (Signature)

2017. 07. 03.

KOSTEC Co., Ltd.

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1. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for DUT are as follows.

Body Worn Configuration

Mode	Freq.	Position	Measured 1 g SAR (W/Kg)	50 % Duty cycle (W/Kg)	Scaled 1 g SAR (W/Kg)	Note
GMRS	462.550 0	Body-worn	0.712	0.356	0.502	

Head Configuration

Mode	Freq.	Position	Measured 1 g SAR (W/Kg)	50 % Duty cycle (W/Kg)	Scaled 1 g SAR (W/Kg)	Note
GMRS	462.550 0	Face-up	0.518	0.259	0.365	

This wireless device has been shown to be capable of compliance for localized specific absorption rate (SAR) for General population/Uncontrolled exposure limits specified in ANSI/IEEE Standards and has been tested in accordance with the measurement procedures specified in IEEE 1528-2013 and RF exposure KDB procedures.

1-1 Test Method List

447498 D01 General RF Exposure Guidance v06

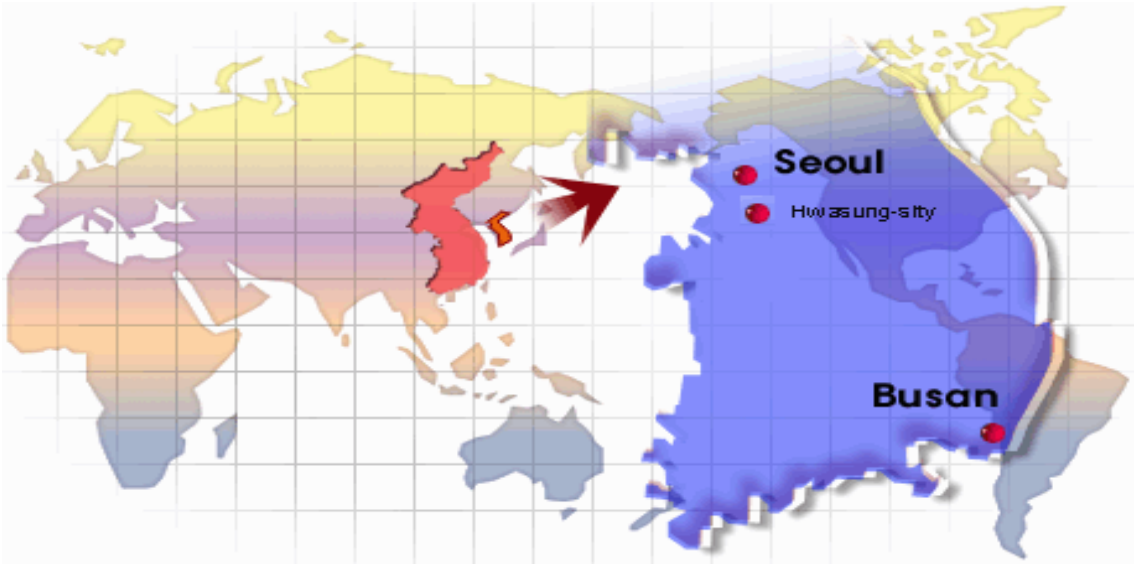
865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04

2. Administration Data

2.1 Test Laboratory

KOSTEC Co., Ltd.
28(175-20,Annyeong-dong)406-gil sejaro, Hwaseong-si Gyeonggi-do, Korea

2.2 Location



2.3 Applicant

Midland Radio Corporation
5900 Parretta Drive, Kansas City, Missouri United States 64120

2.4 Manufacturer

Global Link Corporation Ltd.
21/F Kolling Centre, 77-79 Granville Road, Tsim Sha Tsui Kowloon, Hong Kong

2.5 Application Details

Date of Receipt of application : 2017.06.23
Date of test : 2017. 06. 29.

Revision History of test report

Rev.	Revisions	Effect page	Reviewed	Date
	Initial issue	All	Park, Gyeong Hyeon	2017. 07. 03.

3. GENERAL INFORMATION

3.1 Description of DUT

DUT Type	Family Radio Face Held Transmitter
Device Category	General population/Uncontrolled exposure
Brand Name	-
Model Name	XT511A
Modulation Type	FM
Frequency Range	GMRS/FRS : 462.562 5 MHz - 462.712 5 MHz FRS : 467.562 5 MHz - 467.712 5 MHz GMRS : 462.550 0 MHz - 462.725 0 MHz
Operating mode	Face Up and Body-worn
Body-Worn accessories	Shoulder Strap(None)
Audio accessories	Ear-mic set(AVP-1)
Antenna Specification	Fixed external antenna, 0.45 dBi
Power Source	Ni-MH battery pack / 6.0 VDC nominal / 700 mAh / AA Alkaline battery
Max. Output power	GMRS: 31.52 dBm, FRS: 23.19 dBm
Max.SAR(1 g)	0.502 W/kg
Remark	The above DUT's information was declared by manufacturer. Please refer to the specifications or user manual for more detailed description.
FCC ID	MMAXT511A

3.1.1 The DUT conducted power measurements

Channel Description	CH	Frequency [㎒]	Conducted output Power [dBm]	Conducted output Power [W]	Target power	Max. tune-up tolerance limit	Scaling Factor
GMRS	15	462.550 0	31.52	1.42	32.0	33.0	1.41
FRS	8	467.562 5	23.19	0.21	23.0	24.0	1.21

Note:

1) Scaling Factor = tune-up limit power (㎽) / EUT RF power (㎽)
2) Tune-up tolerance is ± 1 dB.

3.2 Photographs of EUT

Front

Rear

Top

Bottom

Left

Right

3.3 Accessories

Ear-mic set

3.4 Test Condition

3.4.1 Ambient Condition

• Ambient temperature : (20 ~ 21) ℃

• Relative Humidity : (47 ~ 50) % R.H.

3.4.2 Test Configuration

The EUT was tested in the face position with the front of the device 25 mm away from the flat phantom and the body position with the front of the device 25 mm away from the flat phantom. The audio accessory (AVP-1) was used for all body measurements.

For each of the tests conducted, the device was set to continuously transmit at a maximum output power on t he channel specified in the test data. The SAR for analog mode was scaled to 50% duty cycle (as this is the maximum duty cycle of the device)

3.5 Requirements for compliance testing defined by FCC

The US Federal Communications Commission has released the report and order “Guidelines for Evaluating the Environmental Effects of RF Radiation", ET Docket No. 93-62 in August 1996 [1]. The order requires routine SAR evaluation prior to equipment authorization of portable transmitter devices, including portable telephones.
For consumer products, the applicable limit is 1.6 W/kg for an uncontrolled environment and 8.0 W/kg for an occupational/controlled environment as recommended by the ANSI/IEEE standard C95.1.

According to the KDB publications by the FCC, the device should be evaluated at maximum output power (radiated from the antenna) under “worst-case” conditions for normal or intended use, incorporating normal antenna operating positions, device peak performance frequencies and positions for maximum RF energy coupling.

4. Specific Absorption Rate (SAR)

4.1 Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

4.2 SAR Definition

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (Dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dv}\right)$$

SAR is expressed in units of Watts per kilogram (W/kg)

SAR measurement can be either related to the temperature elevation in tissue by

$$SAR = C\left(\frac{\delta T}{\delta t}\right)$$

Where: C is the specific head capacity, δT is the temperature rise and δt is the exposure duration, or related to the electrical field in the tissue by

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

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength.

However, for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

4.3 SAR Measurement Procedure

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

5. SAR Measurement System

[ALSAS-10U System Description]

The CRS F3 robot is a 6 axis articulated robot with a reach of 710 mm and a maximum speed of 1016 mm/s.

The PMDPS is a probe mounting and proximity sensing device mounted on joint 6 of the F3 Robot. The PMDPS purpose is to hold the probe, house the data acquisition hardware and detect the phantom surface. It can detect a flat-phantom surface to a tolerance of +/- 0.5 mm. The PMDPS is also equipped with an E-Stop feature that is designed to protect probes and the user from harm. If the probe collides with an object the E-Stop will be triggered and the robot will stop immediately.

The phantoms sit on top of the workstation and are positioned such that the robot has optimal reach into all areas of each phantom. The system contains a SAM-Left, SAM-Right and a Uni-Phantom TM that can be used as a flat phantom for system validations.

The Device positioner is a plastic positioning device for the DUT. It has 8 degrees of freedom that can be locked individually and a 15 degree touch to tilt feature for fast and accurate repositioning.

The shelves in the ALSAS-10U system can be adjusted to accommodate larger devices. The workstation rests on levellers that can be adjusted to ensure that the system is level.

The system consists of the following components;

1) CRS F3 Robot
2) PMDPS
3) Phantoms
4) Device Positioner
5) Adjustable Shelves
6) Work Station
7) Probes
8) Dipoles (not in picture)

Some of the components are described in details in the following sub-sections.

5.1 E-field Probe

The APREL Laboratories E-Field probe utilizes an orthogonally triangular sensor arrangement.

E-Field Probes have been characterized from 30 MHz to 6 GHz with the probe diameter scientifically verified for use at frequencies above 3 GHz eliminating the need for separate probe types.

The isotropic E-Field probe used by APREL Laboratories, has been fully calibrated and assessed for isotropicity and sensitivity in both air and tissue, including boundary effect within a controlled ISO-IEC 17025 accredited laboratory.

SAR is assessed with the calibrated probe which can be positioned at a user defined or default height(s) of 2.4 or 4 mm from phantom surfaces so as to minimize any resultant boundary effect due to the probe being in close proximity to the phantom surface and provides improved measurement uncertainty at higher frequencies.

A new 2.8 mm probe is now available for use at higher frequencies allowing for smaller scan resolutions and greater measurement point density.

Compliant Standards	IEEE 1528, IEC 62209 Part 1 & 2
Frequency Range	30 MHz ~ 6 GHz
Sensitivity	0.60 $\mu V/(V/m)^2$ to 1.25 $\mu V/(V/m)^2$
Dynamic Range SAR	0.001 W/kg to 100 W/kg
Isotropic Response Axial	Better than 0.2 dB in air Better than 0.05 dB in tissue
Hemispherical isotropy	±0.3 dB or better
Diode Compression Point (DCP)	Calibrated for Specific Frequency typically 95 mV +/- 10 %
Linearity	±0.2 dB or better
Probe Tip Radius	<2.9 mm
Sensor Offset	1.56 (±0.02 mm)
Probe Length	290 mm
Video Bandwidth	@ 500 Hz: 1 dB @ 1K Hz: 3 dB
Boundary Effect	Less than 2 % for distances greater than 1.4 mm
Material	Ertalyte™
Connector	6 Pin Bayonet
Probe Diameter	Less than 2.8 mm

5.2 Device Positioner

The APREL Laboratories Universal Device Positioner has been developed so as to allow complete freedom of movement of a DUT. Developed to hold the DUT in the equivalent of free space to avoid additional loading attributable to the material used in the construction of the positioner so as to reduce measurement uncertainty.

Positioner has a built-in 15 degree feature used for fast and accurate touch to tilt movement.

The APREL device positioner can hold in-place devices such as handsets, smart phones, Clam shell phones, PDA's and small size tablet PC's.

When used with the Universal Work Station and its adjustable shelves, the positioned provides 8 degrees of motion, and does not require the user to crouch or sit on the floor (a stool or chair can be used) when positioning the DUT against a phantom.

Compliant Standards	IEEE 1528, IEC 62209 Part 1 & 2
Dielectric constant	Less than 5.0
Loss Tangent	Less than 0.05
Number of Axis	6 axis freedom of movement (8 when utilized with ALSAS-10U Workstation)
Translation Along MB Line	±76.2 mm
Translation Along NF Line	±38.1 mm
Translation Along Z Axis	±25.4 mm (expandable up to 500 mm)
Rotation Around MB Line (yaw)	±10°
Rotation Around NF (pitch)	±30°
Line Rotation (roll)	360° full circle
Maximum Grip Range	0 mm to 150 mm
Material	Resistant to DGBE and all other tissue stimulant materials
Tilt Movement	Full movement with built-in 15° gauge

5.3 6 Axis Articulated Robot ALS-F3

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.

The accuracy of the probe tip positioning over the measurement area is better than 0.05 mm.

The robot is capable of moving the probe to angles greater than 30°.

Robot positioning repeatability should only be used as a reference when a process has been developed for repeated point to point detection. This value is not relevant to SAR measurements as it is not expected that a user would measure the exact same condition** more than 100 times (as per the robotic manufacturers standard for determining the positional repeatability).

**Condition specified above with respect to SAR measurements would reflect a process executed on a DUT which has been defined, characterized, setup and measured repeatedly without any changes to the setup condition for more than 100 times.

Compliant Standards	IEEE 1528, IEC 62209 Part 1 & 2
Dielectric constant	Less than 5.0
Loss Tangent	Less than 0.05
Number of Axis	6 axis freedom of movement (8 when utilized with ALSAS-10U Workstation)
Translation Along MB Line	±76.2 mm
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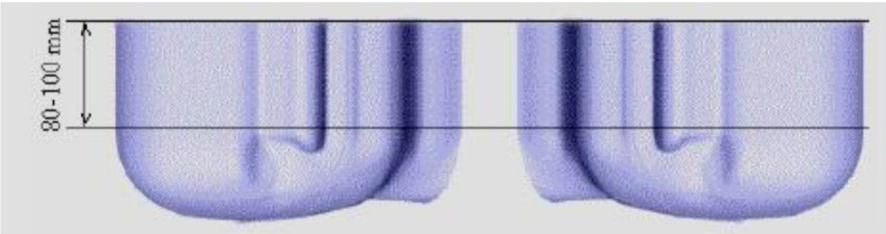
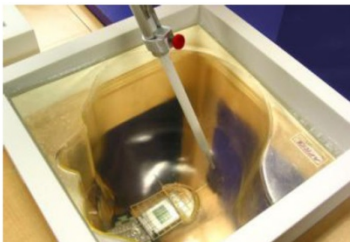
Rotation Around MB Line (yaw)	±10°
Rotation Around NF (pitch)	±30°
Line Rotation (roll)	360° full circle
Maximum Grip Range	0 mm to 150 mm
Material	Resistant to DGBE and all other tissue stimulant materials
Tilt Movement	Full movement with built-in 15° gauge

5.4 SAM Phantoms

The APREL Laboratories 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 IEEE 1528, IEC 62209 Part 1 and 2 (draft) and FCC Supplement C. Both the left and right SAM phantoms are sagitally cut and can be interchangeable on the Universal Workstation. The phantoms are transparent and include the IEEE 1528 grid with visible NF and MB lines. The phantom is surrounded by an Acrylic Polymer Blend frame, which adds additional support and load bearing characteristics.





Compliant Standards	IEEE 1528, IEC 62209 Part 1 & 2
SAM	In accordance with the IEEE 1528 standard & IEC 62209 Part 1
Material	Composite urethane which allows for the device to be viewed through the phantom, resistant to DGBE
Phantom Shell Shape Tolerance	Fully calibrated to be better than ±0.2 mm
Frame Material	Corian®
Tissue Simulation Volume	7 liter with 15.0 ±0.5 cm tissue
Thickness	2 mm ±0.2 mm 6 mm ±0.2 mm at NF/MB intersection
Loss Tangent	<0.05
Relative Permittivity	<5
Resistant to Solvents	Resistant to all solvents used for tissue manufacturing detailed in IEEE 1528 & IEC 62209
Load Deflection	<1 mm with sugar water compositions
Manufacturing Process	Injection Molded
Phantom Weight	Less than 10 kg when filled with 15 cm of simulation tissue

5.5 Flat Phantoms

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, CENELEC, 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 Volume	12.8 liter with a liquid depth of 150 mm
Shell Thickness	2 mm ±0.2 mm
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	340 mm x 270 mm x 225 mm

Additional Phantom Specification Details

- Clear Phantoms for improved positioning of DUT and measurement repeatability provides overall improvement to uncertainty of the SAR measurement.

- Overall phantom shell thickness uncertainty is ±0.2 mm

-Lower volume phantoms need less than 7l of tissue for SAR measurements.

-Corian™ frames with built-in spout for easier tissue evacuation.

-Permanent IEEE 1528 and IEC 62209 positioning reference markings included on phantom for better positioning accuracy, repeatability and improvement to uncertainty of the SAR measurement (see images on next page).

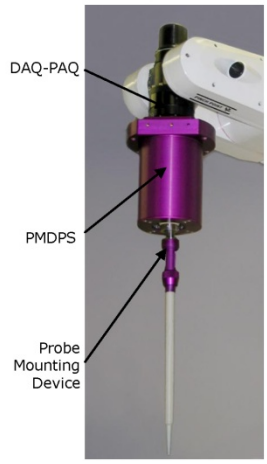
-Additional markings are included on phantoms to improve DUT positioning and accuracy.

-Universal Phantom ™ for use in validation, body, and head SAR evaluations. The Universal Phantom ™ speeds up the measurement process by allowing for left and right measurements to be made in one measurement step (less than 10 minutes for complete process).

-Weight of SAM and Universal Phantom ™ when filled is less than 10 kg.

-After test completion phantoms and tissue can be placed in storage box until next use.

5.6 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, combined with the integrated amplifier module. The input signal is amplified accordingly so as to offer a dynamic range from 4 µV to 330 mV. Integration of the fields measured is carried out at board level utilizing a Co-Processor utilizing proprietary algorithms. Improvements to measurement speed are improved by sending processed data down to the main computational module.

PMDPS is used to hold a probe and to detect complex boundary locations (curved and flat surfaces) during a SAR or HAC assessment process. It utilizes relative movements of internal components to trigger integrated micro-sensor mechanisms in order to detect boundary(s) and consequently position the probe at the specified distance relative to a boundary in order to achieve accurate and repeatable measurements.

All surface detection methods are controlled by a proprietary algorithm which dynamically compensates for every detection point, and allows for a 20-30% improvement to surface detection speeds. By eliminating optical detection sensors uncertainty is further reduced by integrating micro detection sensors which can determine movements of less than 1µm.

Amplifier Range	4 µV to 330 mV
ADC	16 Bit optically isolated
Built-in E-Stop Feature	Emergency Stop feature to prevent damage of equipment and for user safety purposes
Field Integration	Local Co-Processor utilizing proprietary integration algorithms
SAR Dynamic Range	0.001 W/kg ~ 100 W/kg.
Ambient Noise	Below 0.001 W/kg measured with probe in tissue
LED Indication	Boundary detection and DAQ-PAQ State
Number of Input Channels	4 in total 3 dedicated and 1 spare for future upgrades
Communication	Optically isolated packet data via RS232
Robot Arm Integration	DAQ-PAQ and Boundary Detection Unit are mounted directly onto joint 6 of the F3 arm utilizing joint 6 tool (ISO Standard M8 Mounting Plate) to allow easy integration and removal (no angular interface)
Supply	DC supply powered by an isolated external supply unit
LED Indicators	Probe status (amplifier on) and boundary detection

Additional PMDPS Specification Details:

- Accuracy of Positioning: Better than 10 µm at 6 GHz.
- SAR Uncertainty: Better than 0.01 W/kg SAR at 6 GHz.
- Detection Mechanism: 2 x 360° Stage Axial and Lateral Detection at 6 GHz.
- Emergency Stop: 4 Stage 360° Axial and Lateral Detection at 6 GHz.
- Probe Mounting: 6 Pin Bayonet for Fast Probe Change.
- Calibration: Every PMDPS is Calibrated to 0.01 W/kg SAR at 6 GHz.

5.7 Validation Dipoles

APREL have developed a range of dipoles for use in dosimetric (SAR) and near/far field applications.

Validation dipoles have been designed using the data presented in IEEE-1528, IEC-62209 1&2.

All tuned dipoles have a return loss grater than -20 dBm, for dosimetric applications.

Compliant Standards	EEE 1528, IEC 62209 Part 1 & 2,EN50361
Electrical	Symmetrical Dipole with variable λ/divisor
Frequency range	30 MHz ~ 6 GHz
Application	Tuned for Dosimetric System Validation
Material	Rigid Coated Brass
Dipole Diameter	1.805 mm From Center (3.6 mm)
Calibration	Return Loss, Standing Wave Ratio, Impedance & 1 & 10 g Averages
Length	Dependent on Specification
Return Loss	Above -20 dBm
Max Power Input	100 W

5.8 Test Equipment List

No.	Instrument	Manufacturer	Model	S/N	Due to cal date	Cal interval	used
1	The Teach Pedant	Thermo ELECTRON CORPORATION	STP 500	STP0502506	N/A	N/A	☐
2	Universal Phantom	APREL Laboratories	ALS-P-UP-1	None	N/A	N/A	☐
3	Flat Phantom	APREL Laboratories	ALS-UM-FLAT	153-00102	N/A	N/A	☒
4	Left Ear SAM Phantom	APREL Laboratories	ALS-P-SAM-L	130-00316	N/A	N/A	☐
5	Right Ear SAM Phantom	APREL Laboratories	ALS-P-SAM-R	140-00367	N/A	N/A	☐
6	6 Axis Articulated Robot	Thermo CRS	ALS-F3	RAF0504263	N/A	N/A	☒
7	C500C CONTROLLER FOR F3 ROBOTS	Thermo CRS	UMI-R3-310	RCF0503290	N/A	N/A	☒
8	Data Acquisition Package	APREL Laboratories	ALS-DAQ-PAQ-3	110-00204	N/A	N/A	☒
9	Probe Mounting Device and Boundary Detection Sensor System	APREL Laboratories	ALS-PMDPS-3	120-00269	N/A	N/A	☒
10	Device Holder	APREL Laboratories	ALS-H-E-SET-2	170-00507	N/A	N/A	☒
11	Reference Dipole	APREL Laboratories	ALS-D-450-S-2	175-00504	2017.08.28	2 Year	☒
12	Reference Dipole	APREL Laboratories	ALS-D-600-S-2	174-00101	2018.08.02	2 Year	☐
13	Reference Dipole	APREL Laboratories	ALS-D-750-S-2	177-00507	2017.11.09	2 Year	☐
14	Reference Dipole	APREL Laboratories	ALS-D-835-S-2	180-00555	2019.02.03	2 Year	☐
15	Reference Dipole	APREL Laboratories	ALS-D-900-S-2	190-00614	2019.02.03	2 Year	☐
16	Reference Dipole	APREL Laboratories	ALS-D-1800-S-2	200-00656	2019.02.06	2 Year	☐
17	Reference Dipole	APREL Laboratories	ALS-D-1900-S-2	210-00717	2019.02.06	2 Year	☐
18	Reference Dipole	APREL Laboratories	ALS-D-2450-S-2	220-00764	2019.02.06	2 Year	☐
19	Reference Dipole	APREL Laboratories	ALS-D-BB-S-2	235-00807	2019.02.06	2 Year	☐
20	Miniature E-Field Probe	APREL Laboratories	ALS-E-020	271	2017.08.02	1 Year	☒
21	Low pass filter	WAINWRIGMCS INSTRUMNENTS GMBH	WLJS1000-6EF	1	2018.02.02	1 Year	☒
22	Low pass filter	WAINWRIGMCS INSTRUMNENTS GMBH	WLJS2500-6EF	1	2018.02.02	1 Year	☐
23	High pass Filter	WAINWRIGMCS INSTRUMNENTS GMBH	WHJS3000-10EF	1	2018.02.02	1 Year	☐
24	Dual directional coupler	HEWLETT PACKARD	778D	17693	2018.02.02	1 Year	☒
25	Dual directional coupler	HEWLETT PACKARD	772D	2839A00924	2018.02.02	1 Year	☐
26	3.5 ㎜ Cal. Kit	Agilent Technologies	85033D	3423A07123	N/A	N/A	☒
27	3 dB Attenuator	Weinschel Corp	23-3-34	BK2093	2017.12.27	1 Year	☒
28	Attenuator	Aeroflex / Weinschel	24-30-34	BX5630	2017.12.27	1 Year	☒
29	EPM Series Power meter	Agilent Technology	E4418B	MY41293610	2018.02.03	1 Year	☒
30	Power sensor	Agilent Technology	E9300A	MY41496666	2018.02.03	1 Year	☒
31	EPM Series Power meter	Agilent Technology	E4418B	GB39512547	2018.02.01	1 Year	☒
32	Power Sensor	Agilent Technology	E9300A	MY41496631	2018.02.01	1 Year	☒
33	RF Amplifier	Sung san Electronics Communications	SSA024	SSEC0001	2018.02.03	1 Year	☒
34	Signal Generator	ROHDE&SCHWARZ	SMBV100A	257557	2018.02.02	1 Year	☒
35	Network Analyzer	Agilent	8753ES	US39170869	2017.09.06	1 Year	☒
36	Wideband Radio Communication Tester	ROHDE&SCHWARZ	CMW500	127302	2018.02.03	1 Year	☐
37	85070E.Dielectric Probe kit	Agilent	85070 E	None	N/A	N/A	☐

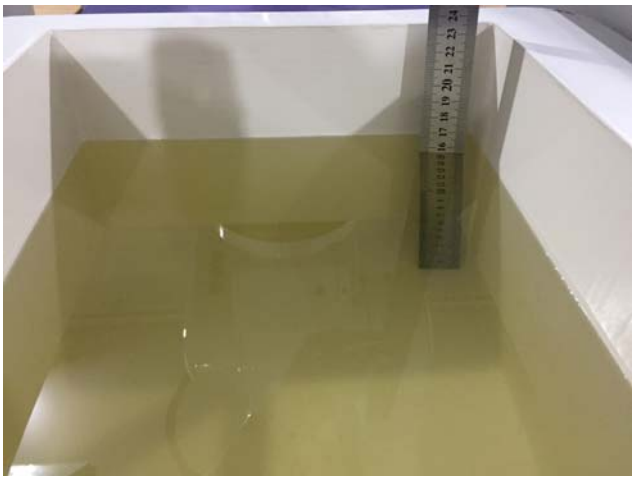
6. Measurement Results

6.1 Tissue Simulating Liquids

The simulating liquids should be checked at the beginning of a series of SAR measurements to determine of the dielectric parameters are within the tolerances of the specified target values. The uncertainty due to the liquid conductivity and permittivity arises from two different sources. The first source of error is the deviation of the liquid conductivity from its target value (max± 5 %)

For head SAR testing, the liquid height from the ear reference point of the phantom to the liquid top surface is larger than 15 cm. for body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm.

Head Tissue



Body Tissue

[Photo of liquid height for SAR testing]

6.1.1 Recipes for tissue simulating liquid.

Ingredients (% by weight)	Freq. (MHz)	
	450	
Tissue Type	Head	Body
Water	38.56	51.16
Salt (NaCl)	3.95	1.49
Sugar	56.32	46.78
HEC	0.98	0.52
Bactericide	0.19	0.05
Triton X-100	0.00	0.00
DGBE	0.00	0.00
Dielectric Constant	43.42	58.0
Conductivity (S/m)	0.85	0.83

6.1.2 Simulated tissue liquid parameter confirmation

The head and Body tissue dielectric parameters recommended by the KDB865664 D01 have been incorporated in the following table.

Target Frequency (MHz)	Head		Body	
	εr	σ (S/m)	εr	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	**43.5**	**0.87**	**56.7**	**0.94**
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 - 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00
(εr = relative permittivity, σ = conductivity and ρ = 1000 kg/m3)				

6.1.3 Measuring result for simulating liquid

Liquid		Parameters	Target	Measured	Deviation (%)	Limit (%)	Date	Note
Freq. (MHz)	Temp. (°C)							
450.000 0	20	Permitivity	43.5	43.56	0.14	±5	2017.06.29	Head tissue
		Conductivity	0.87	0.88	1.15	±5		
462.550 0	20	Permitivity	43.5	43.28	0.51	±5		
		Conductivity	0.87	0.89	2.30	±5		
467.562 5	20	Permitivity	43.5	43.17	0.76	±5		
		Conductivity	0.87	0.89	2.30	±5		
450.000 0	20	Permitivity	56.7	55.34	2.40	±5	2017.06.29	Body tissue
		Conductivity	0.94	0.94	0.00	±5		
462.550 0	20	Permitivity	56.7	55.09	2.84	±5		
		Conductivity	0.94	0.95	1.06	±5		
467.562 5	20	Permitivity	56.7	54.99	3.02	±5		
		Conductivity	0.94	0.95	1.06	±5		

Note: Please see appendix for the plot of measured tissue.

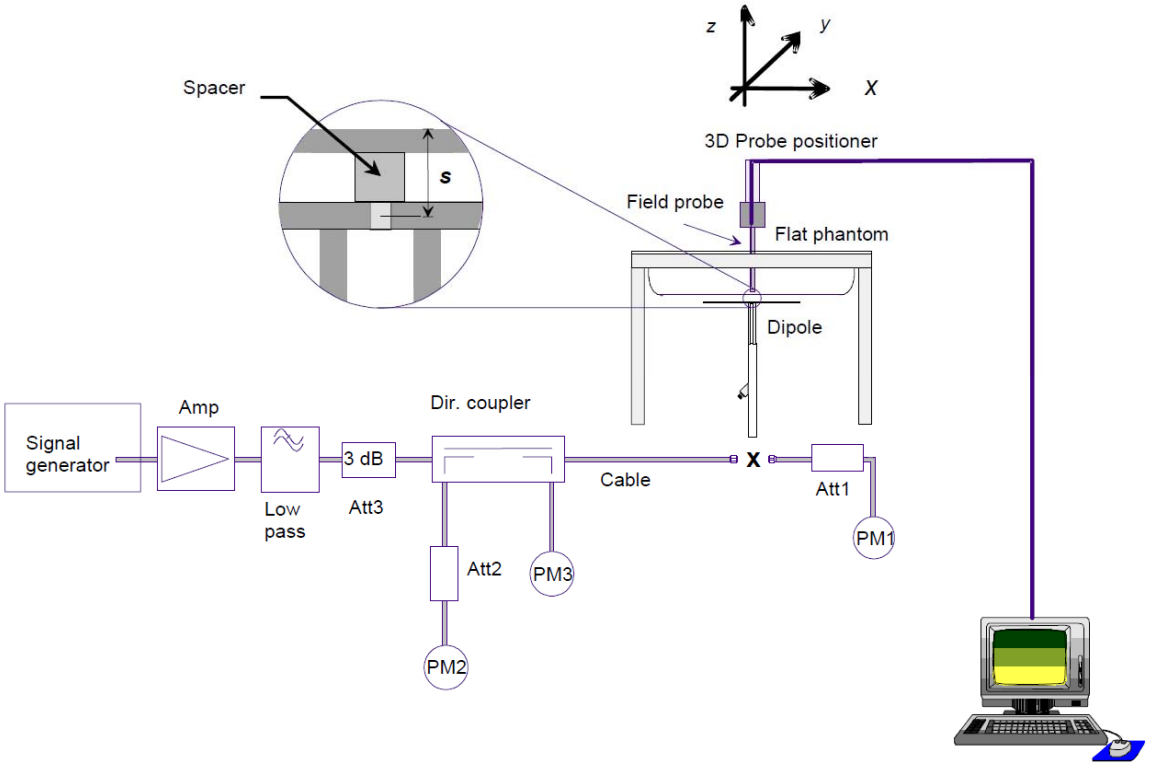
6.2 System Verification

6.2.1 Purpose of system performance check

The system performance check is performed prior to any usage of the system in order to guarantee reproducible results. The system performance check verifies that the system operates within its specifications of ±5 %. Since the SAR value is calculated from the measured electric field, dielectric constant and conductivity of the body tissue and the SAR is proportional to the square of the electric field. So, the SAR value will be also proportional to the RF power input to the system validation dipole under the same test environment. In our system validation test, 100 mW RF dipole input power was used. The 1 g and 10 g spatial average SAR values normalized to 1 W dipole input power give reference data for comparisons and it's equal to 10 x (dipole forward power)

6.2.2 System setup

In the simplified setup for system evaluation, the DUT is replaced by a calibrated dipole and power source is replaced by a continuous wave that comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom with the correct distance spacer. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the short side of the phantom. The equipment setup is shown below:



[System set-up for system verification]

[Photo of dipole setup]

6.2.3 Verification Results

Freq [MHz]	Test Results								Date	Tissue Type
	Measured 1 g SAR [W/kg]		Measured 10 g SAR [W/kg]		Target					
					1 g SAR	10 g SAR	1 g Dev.	10 g Dev.		
	100 mW	1 W	100 mW	1 W	[W/kg]	[W/kg]	[%]	[%]		
450	0.440	4.40	0.288	2.88	4.65	3.047	-5.38	-5.48	2017.06.29	Head
450	0.420	4.20	0.284	2.84	4.43	2.997	-5.19	-5.24	2017.06.29	Body

Note:

1. Comparing to the original SAR value provided by APREL, the validation data should be within its specification of 10 %. Above table shows the target SAR and measured SAR after normalized to 1 W input power.

2. Please see appendix for the plot of system verification test.

6.3 DUT Testing Position

Please see appendix for the DUT setup photos

6.4 SAR measurement procedure

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

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

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength.

The measurement procedures are as follows:

1) For DUT, using engineering software and (or) radio communication tester to transmit RF power continuously in the middle channel.
2) Mesure output power through RF cable and power meter.
3) Place the DUT in the positions described in the appendix for the DUT setup photos.
4) set area scan, grid size and other setting on the ALSAS-10U software.
5) Taking data for the middle channel on each testing position.
6) Find out the largest SAR result on these testing positions of each band
7) measure SAR results for the lowest and highest channels in worst SAR testing position.

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

6.5 SAR Exposure Limits

Type of Exposure	SAR Limit(W/kg)	
	(General Population /Uncontrolled Exposure Environment)	(Occupational / Controlled Exposure Environment)
Spatial Average (averaged over the whole body)	0.08	0.4
Spatial Peak (averaged over any 1 g of tissue)	1.6	8.0
Spatial Peak (hands/wrists/feet/ankles averaged over 10 g)	4.0	20.0

6.6 SAR test result

HEAD Configuration

No	Mode	Freq.	CH	Test Position	Cond Pwr. (dBm)	Power Drift (%)	Measured 1 g SAR (W/Kg)	50 % Duty cycle	Scaled 1 g SAR (W/Kg)	Scaling factor	Limit (W/Kg)	NOTE
1	GMRS	462.550 0	15	Face-up (Ni-MH battery pack)	31.52	-1.238	0.518	0.259	0.365#1	1.41	1.6	2.5 cm
2	FRS	467.562 5	8	Face-up (Ni-MH battery pack)	23.19	-3.261	0.144	0.072	0.087	1.21	1.6	

BODY Configuration

No	Mode	Freq.	CH	Test Position	Cond Pwr. (dBm)	Power Drift (%)	Measured 1 g SAR (W/Kg)	50 % Duty cycle	Scaled 1 g SAR (W/Kg)	Scaling factor	Limit (W/Kg)	NOTE
1	GMRS	462.550 0	15	body-worn (Ni-MH battery pack)	31.52	-2.341	0.712	0.356	0.502#2	1.41	1.6	2.5 cm
2	FRS	467.562 5	8	body-worn (Ni-MH battery pack)	23.19	-4.158	0.331	0.166	0.200	1.21	1.6	

Note:

1. 50% duty cycle only applies to PTT devices.

2. Only one body-worn accessory(Shoulder Strap) and one audio accessory(ear/mic: AVP-1) are supplied with a EUT.

3. The EUT supports Ni-MH battery pack and AA Alkaline battery, the SAR value is less than half of the limit (0.8 W/Kg), SAR measurement for additional batteries is optional.

4. # means the Plot's number.

Repeated SAR test Result

No	Mode	Freq.	CH	Test Position	Measured 1 g SAR (W/Kg)			Ratio	NOTE
					Original	1st Repeat	2nd Repeat		
-	-	-	-	-	-	-	-	-	-
Note: Not Applicable.									

SAR Measurement Variability

In accordance with published RF Exposure KDB procedure 865664 D01 SAR measurement 100 MHz to 6 GHz v01. These additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results

1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.

2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.

3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).

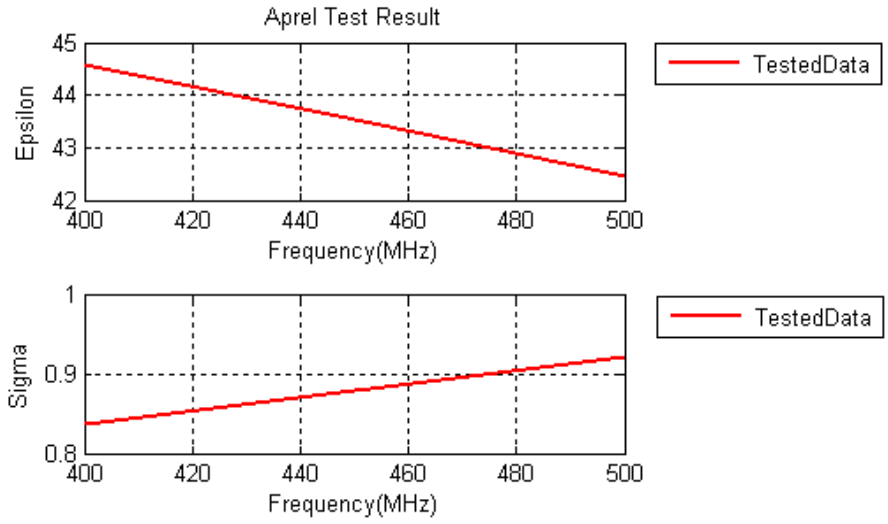
4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

7. Uncertainty Assessment

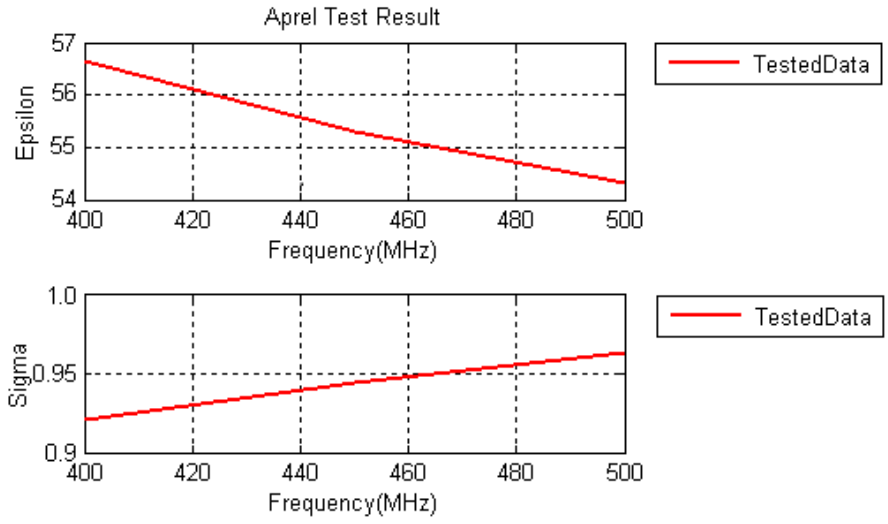
Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	c_i^1 (1-g)	c_i^1 (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %
Measurement System							
Probe Calibration	3.5	normal	1	1	1	3.5	3.5
Axial Isotropy	3.7	rectangular	√3	$(1-cp)^{1/2}$	$(1-cp)^{1/2}$	1.5	1.5
Hemispherical 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	2.2	rectangular	√3	1	1	1.3	1.3
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.)	1.2	normal	1	0.7	0.5	0.8	0.6
Liquid Permittivity(target)	5.0	rectangular	√3	0.6	0.5	1.7	1.4
Liquid Permittivity(meas.)	0.1	normal	1	0.6	0.5	0.1	0.1
Combined Uncertainty		RSS				8.5	8.4
Combined Uncertainty (coverage factor = 2)		Normal(k=2)				17.1	16.8

[Exposure Assessment Measurement Uncertainty]

Appendix A : Plot of measured tissue.



450 MHz Head



450 MHz Body

Measuring result table for simulating liquid

450 MHz Head

Freq	Test_e	Test_s
0.4000	44.60	0.84
0.4500	43.56	0.88
0.4625500	43.28	0.89*
0.4675625	43.17	0.89*
0.5000	42.46	0.91

*value interpolated

450 MHz Body

Freq	Test_e	Test_s
0.4000	56.64	0.92
0.4500	55.34	0.94
0.4625500	55.09	0.95*
0.4675625	54.99	0.95*
0.5000	54.34	0.96

*value interpolated

Appendix B : Plot of system verification test.

▣ 450MHz Head

SAR Test Report

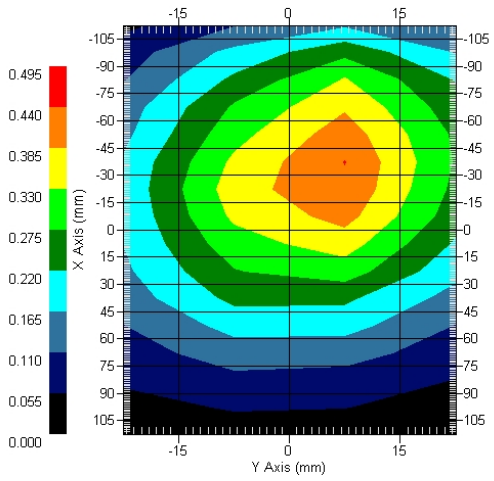
```
Report Date      : 29-Jun-2017
By Operator      : 123
Measurement Date  : 29-Jun-2017
Starting Time     : 29-Jun-2017  09:07:54 AM
End Time         : 29-Jun-2017  09:35:09 AM
Scanning Time     : 1635 secs

Product Data
Device Name      : 450 MHz Dipole
Serial No.       : 175-00504
Type            : Dipole
Model           : ALS-D-450-S-2
Frequency        : 450.00 MHz
Max. Transmit Pwr : 0.1 W
Drift Time       : 10 min(s)
Length          : 298 mm
Width           : 3.6 mm
Depth           : 3.6 mm
Orientation      : Rotated Right 90°
Power Drift-Start : 0.418 W/kg
Power Drift-Finish: 0.409 W/kg
Power Drift (%)   : -2.153
Picture          :

Phantom Data
Name            : APREL-Uni
Type            : Uni-Phantom
Size (mm)        : 280 x 280 x 200
Serial No.       : System Default
Location        : Center
Description      : Default

Tissue Data
Type            : HEAD
Serial No.       : 450H
Frequency        : 450.00 MHz
Last Calib. Date : 29-Jun-2017
Temperature      : 20.00 °C
Ambient Temp.    : 21.00 °C
Humidity        : 50.00 RH%
Epsilon         : 43.56 F/m
Sigma           : 0.88 S/m
Density         : 1000.00 kg/cu. m
```

Probe Data
Name : E-Field
Model : E-020
Type : E-Field Triangle
Serial No. : 271_CW
Last Calib. Date : 29-Jun-2017
Frequency : 450.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 6.1
Probe Sensitivity: 1.20 1.20 1.20 μV/(V/m)^2
Compression Point: 95.00 mV
Offset : 1.56 mm

Measurement Data
Crest Factor : 1
Scan Type : Complete
Tissue Temp. : 20.00 °C
Ambient Temp. : 21.00 °C
Set-up Date : 29-Jun-2017
Set-up Time : 09:05:14 AM
Area Scan : 16x4x1 : Measurement x=15mm, y=15mm, z=4mm
Zoom Scan : 7x7x7 : Measurement x=5mm, y=5mm, z=5mm

Other Data
DUT Position : Rotated Right 90°
Separation : 15
Channel : Mid

Area Scan



1 gram SAR value : 0.440 W/kg
10 gram SAR value : 0.288 W/kg
Area Scan Peak SAR : 0.443 W/kg
Zoom Scan Peak SAR : 0.662 W/kg

▣ 450MHz Body

SAR Test Report

Report Date : 29-Jun-2017
By Operator : 123
Measurement Date : 29-Jun-2017
Starting Time : 29-Jun-2017 02:05:34 PM
End Time : 29-Jun-2017 02:32:41 PM
Scanning Time : 1627 secs

Product Data
Device Name : 450 MHz Dipole
Serial No. : 175-00504
Type : Dipole
Model : ALS-D-450-S-2
Frequency : 450.00 MHz
Max. Transmit Pwr : 0.1 W
Drift Time : 10 min(s)
Length : 298 mm
Width : 3.6 mm
Depth : 3.6 mm
Orientation : Rotated Right 90°
Power Drift-Start : 0.429 W/kg
Power Drift-Finish: 0.419 W/kg
Power Drift (%) : -2.331
Picture :

Phantom Data
Name : APREL-Uni
Type : Uni-Phantom
Size (mm) : 280 x 280 x 200
Serial No. : System Default
Location : Center
Description : Default

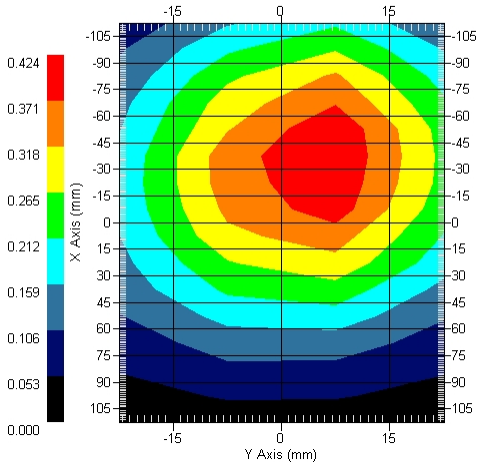
Tissue Data
Type : BODY
Serial No. : 450B
Frequency : 450.00 MHz
Last Calib. Date : 29-Jun-2017
Temperature : 20.00 °C
Ambient Temp. : 21.00 °C
Humidity : 50.00 RH%
Epsilon : 55.34 F/m
Sigma : 0.94 S/m
Density : 1000.00 kg/cu. m

Probe Data
Name : E-Field
Model : E-020
Type : E-Field Triangle
Serial No. : 271_CW
Last Calib. Date : 2-Aug-2016
Frequency : 450.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 6.3
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
Tissue Temp. : 20.00 °C
Ambient Temp. : 21.00 °C
Set-up Date : 29-Jun-2017
Set-up Time : 02:03:14 PM
Area Scan : 16x4x1 : Measurement x=15mm, y=15mm, z=4mm
Zoom Scan : 7x7x7 : Measurement x=5mm, y=5mm, z=5mm

Other Data
DUT Position : Rotated Right 90°
Separation : 15

Area Scan



1 gram SAR value : 0.420 W/kg
10 gram SAR value : 0.284 W/kg
Area Scan Peak SAR : 0.423 W/kg
Zoom Scan Peak SAR : 0.601 W/kg

Appendix C : Plot of SAR test.

Test Plot list

No	Mode	Freq.	CH	Test Position	Measured 1 g SAR (W/Kg)	50 % Duty cycle	Scaled 1 g SAR (W/Kg	NOTE
1	GMRS	462.550 0	15	Face-up	0.518	0.259	0.365[#1]	
2	GMRS	462.550 0	15	Body-worn	0.712	0.356	0.502[#2]	

No	Mode	Freq.	CH	Test Position
1	GMRS	462.550 0	15	Face-up

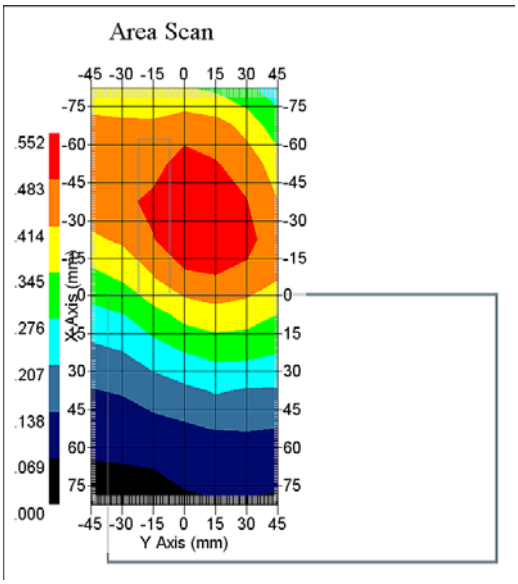
SAR Test Report

```
Report Date      : 29-Jun-2017
By Operator      : 123
Measurement Date  : 29-Jun-2017
Starting Time     : 29-Jun-2017  12:51:12 PM
End Time         : 29-Jun-2017  01:21:38 PM
Scanning Time     : 1826 secs

Product Data
Device Name      : Midland Radio Corporation
Serial No.       : Proto type
Type            : Other
Model           : XT511A
Frequency        : 4625500.00 MHz
Max. Transmit Pwr : 1.4 W
Drift Time       : 10 min(s)
Length          : 125 mm
Width           : 185 mm
Depth           : 50 mm
Antenna Type     : Whip
Orientation      : Touch
Power Drift-Start : 0.323 W/kg
Power Drift-Finish: 0.319 W/kg
Power Drift (%)   : -1.238
Picture          :

Phantom Data
Name           : APREL-Uni
Type           : Uni-Phantom
Size (mm)       : 280 x 280 x 200
Serial No.      : System Default
Location        : Center
Description     : Default


Tissue Data
Type           : HEAD
Serial No.      : 450H
Frequency       : 462.55 MHz
Last Calib. Date : 29-Jun-2017
Temperature     : 20.00 °C
Ambient Temp.    : 21.00 °C
Humidity        : 50.00 RH%
Epsilon         : 43.28 F/m
Sigma           : 0.89 S/m
Density         : 1000.00 kg/cu. m
```

Probe Data
Name : E-Field
Model : E-020
Type : E-Field Triangle
Serial No. : 271_CW
Last Calib. Date : 02-Aug-2016
Frequency : 450.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 6.1
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
Scan Type : Complete
Tissue Temp. : 20.00 °C
Ambient Temp. : 21.00 °C
Set-up Date : 29-Jun-2017
Set-up Time : 12:50:28 PM
Area Scan : 12x7x1 : Measurement x=15mm, y=15mm, z=4mm
Zoom Scan : 7x7x7 : Measurement x=5mm, y=5mm, z=5mm

Other Data
DUT Position :
Separation : 25
Channel : Mid



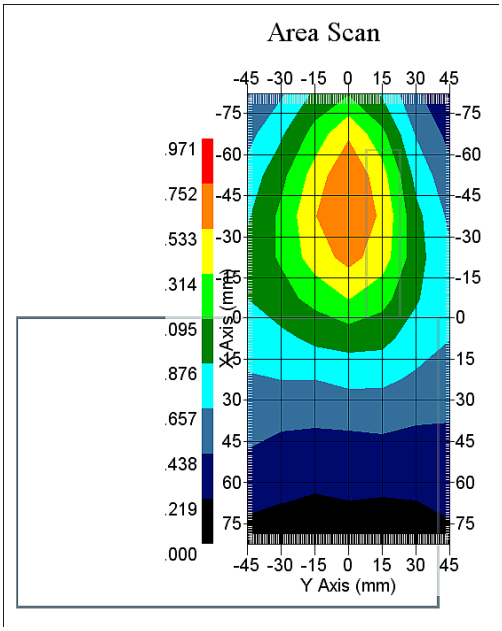
1 gram SAR value : 0.518 W/kg
10 gram SAR value : 0.587 W/kg
Area Scan Peak SAR : 0.552 W/kg
Zoom Scan Peak SAR : 0.700 W/kg

No	Mode	Freq.	CH	Test Position
2	GMRS	462.550 0	15	Body-worn

SAR Test Report

```
Report Date      : 29-Jun-2017
By Operator      : 123
Measurement Date  : 29-Jun-2017
Starting Time    : 29-Jun-2017  05:07:04 PM
End Time         : 29-Jun-2017  05:37:15 PM
Scanning Time    : 1811 secs

Product Data
Device Name      : Midland Radio Corporation
Serial No.       : Proto type
Type            : Other
Model           : XT511A
Frequency        : 4625500.00 MHz
Max. Transmit Pwr : 1.4 W
Drift Time       : 10 min(s)
Length          : 125 mm
Width           : 185 mm
Depth           : 50 mm
Antenna Type     : Whip
Orientation      : Touch
Power Drift-Start : 0.769 W/kg
Power Drift-Finish: 0.751 W/kg
Power Drift (%)   : -2.341
Picture          :

Phantom Data
Name            : APREL-Uni
Type            : Uni-Phantom
Size (mm)        : 280 x 280 x 200
Serial No.       : System Default
Location        : Center
Description      : Default

Tissue Data
Type            : BODY
Serial No.       : 450B
Frequency        : 462.55 MHz
Last Calib. Date : 29-Jun-2017
Temperature      : 20.00 °C
Ambient Temp.    : 21.00 °C
Humidity        : 50.00 RH%
Epsilon         : 55.09 F/m
Sigma           : 0.95 S/m
Density         : 1000.00 kg/cu. m
```

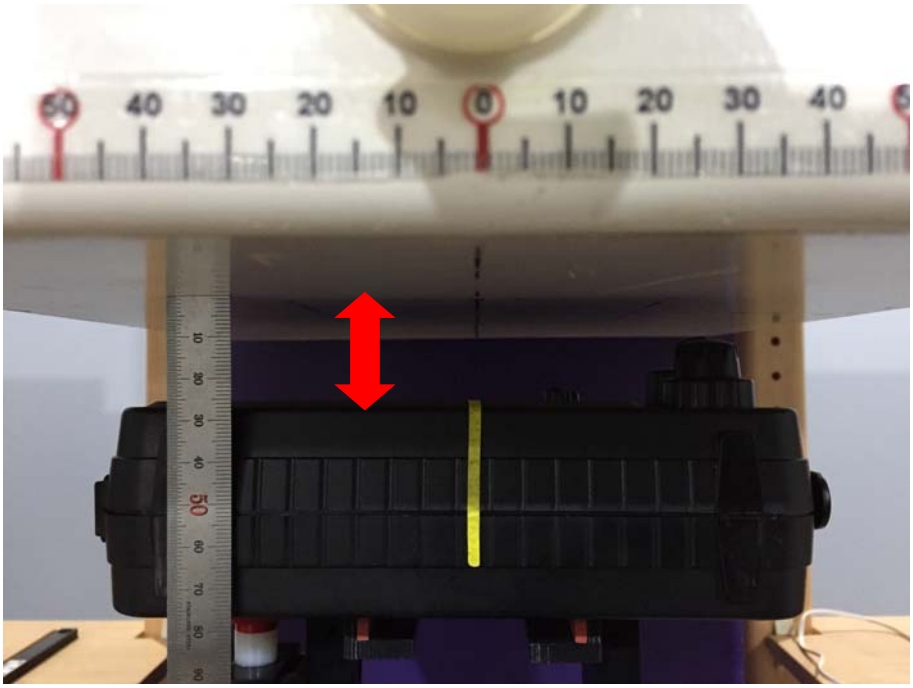
```
Probe Data
Name            : E-Field
Model           : E-020
Type            : E-Field Triangle
Serial No.       : 271_CW
Last Calib. Date : 02-Aug-2016
Frequency       : 450.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 6.3
Probe Sensitivity: 1.20  1.20  1.20   µV/(V/m)²
Compression Point: 95.00 mV
Offset          : 1.56 mm

Measurement Data
Crest Factor     : 1
Scan Type        : Complete
Tissue Temp.     : 20.00 °C
Ambient Temp.    : 21.00 °C
Set-up Date      : 29-Jun-2017
Set-up Time      : 5:04:16 PM
Area Scan        : 12x7x1 : Measurement x=15mm, y=15mm, z=4mm
Zoom Scan        : 7x7x7 : Measurement x=5mm, y=5mm, z=5mm

Other Data
DUT Position     :
Separation       : 25
Channel          : Mid
```




```
1 gram SAR value   : 0.712 W/kg
10 gram SAR value  : 0.349 W/kg
Area Scan Peak SAR : 0.753 W/kg
Zoom Scan Peak SAR : 0.942 W/kg
```

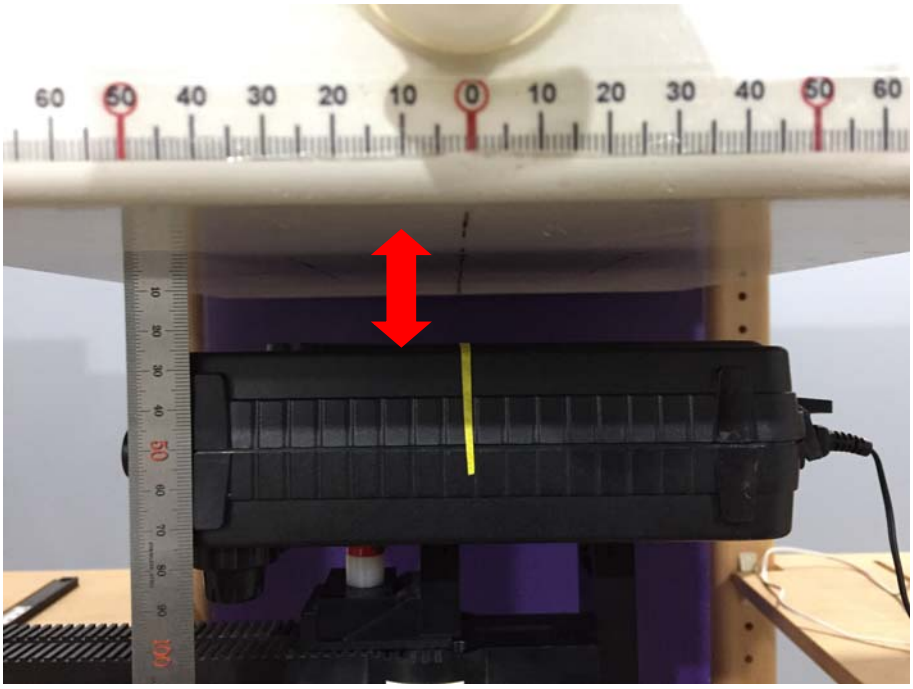
Appendix D: DUT setup photos

Face held configration



[FRONT]

Body worn configuration



[REAR]

Appendix E: System Certificate & calibration

E-1: Probe Calibration

NCL CALIBRATION LABORATORIES

Calibration File No.: PC-1687
Task No: 5819

Client.: Kostec Co. Ltd.
Address: 28, 406-gil sejaro,
Hwaseong-si, Gyeonggi-do, 180-254, Korea

CERTIFICATE OF CALIBRATION

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.: 500-00271

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

Calibrated: 2nd August 2016
Released on: 4th August 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
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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

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Conditions

Probe 500-00271 was a recalibration.

Ambient Temperature of the Laboratory:	20 °C +/- 0.5°C
Temperature of the Tissue:	20 °C +/- 0.5°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.

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

Dan Brooks, Test Engineer

Page 3 of 9 Probe S/N 500-00271
This page has been reviewed for content and attested to on Page 2 of this document

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Probe Summary

Probe Type:	E-Field Probe E020
Serial Number:	500-00271
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, $\mu V/(V/m)^2$
450 MHz	1.202	1.204	1.198	±0.004

*Resistive to recommended tissue recipes per IEEE-1528

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Calibration for Tissue (Head H, Body B)

Frequency	Tissue Type	Measured Epsilon	Measured Sigma	Standard Uncertainty (%)	Calibration Frequency Range (MHz)	Conversion Factor
450 H	**Head**	**45.21**	**0.858**	**3.5**	**±50**	**6.1**
450 B	**Body**	**56.77**	**0.92**	**3.5**	**±50**	**6.3**
600 H	Head	X	X	X	X	X
750 H	Head	X	X	X	X	X
750 B	Body	X	X	X	X	X
835 H	Head	X	X	X	X	X
835 B	Body	X	X	X	X	X
900 H	Head	X	X	X	X	X
900 B	Body	X	X	X	X	X
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	X	X	X	X	X
1750 B	Body	X	X	X	X	X
1800 H	Head	X	X	X	X	X
1800 B	Body	X	X	X	X	X
1900 H	Head	X	X	X	X	X
1900 B	Body	X	X	X	X	X
2000 H	Head	X	X	X	X	X
2000 B	Body	X	X	X	X	X
2100 H	Head	X	X	X	X	X
2100 B	Body	X	X	X	X	X
2300 H	Head	X	X	X	X	X
2300 B	Body	X	X	X	X	X
2450 H	Head	X	X	X	X	X
2450B	Body	X	X	X	X	X
2600 H	Head	X	X	X	X	X
2600 B	Body	X	X	X	X	X
3000 H	Head	X	X	X	X	X
3000 B	Body	X	X	X	X	X
3600 H	Head	X	X	X	X	X
3600 B	Body	X	X	X	X	X
5200 H	Head	X	X	X	X	X
5300 H	Head	X	X	X	X	X
5600 H	Head	X	X	X	X	X
5800 H	Head	X	X	X	X	X

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This page has been reviewed for content and attested to on Page 2 of this document

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**

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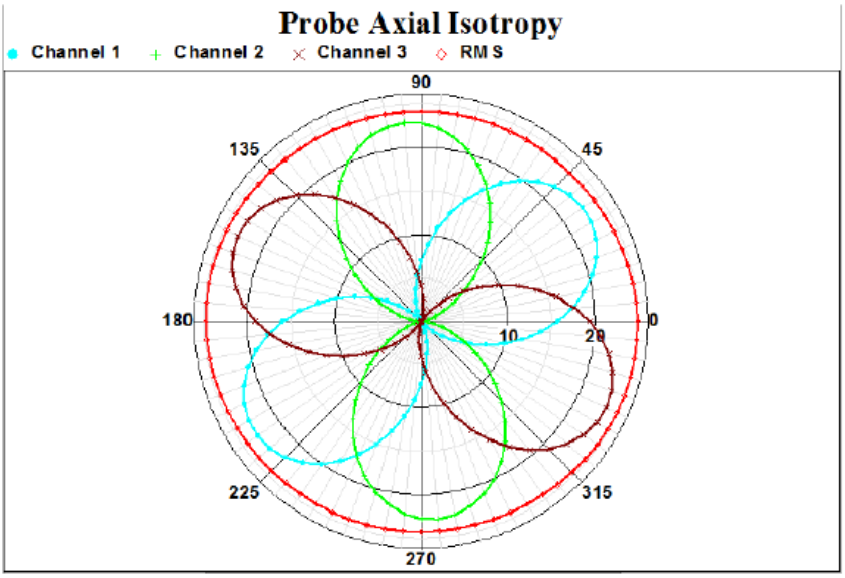
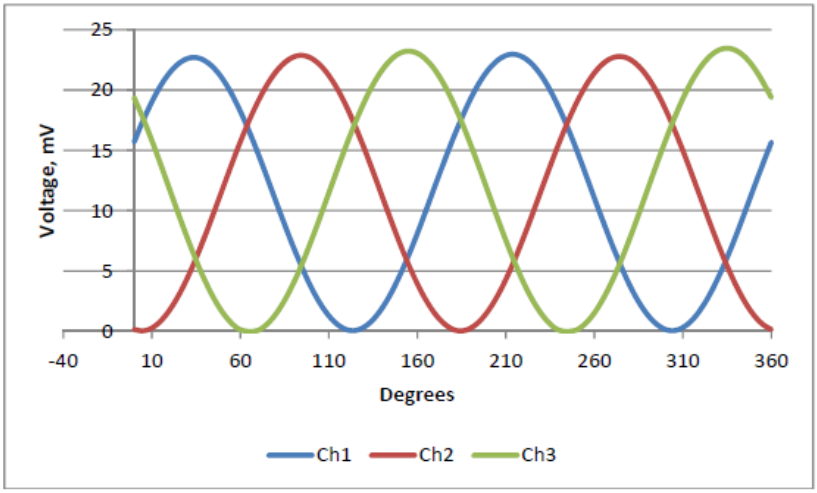
Receiving Pattern Air





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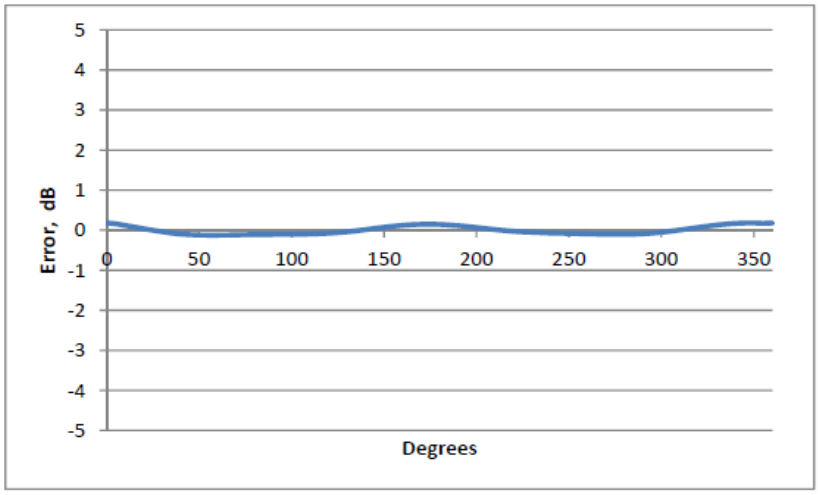
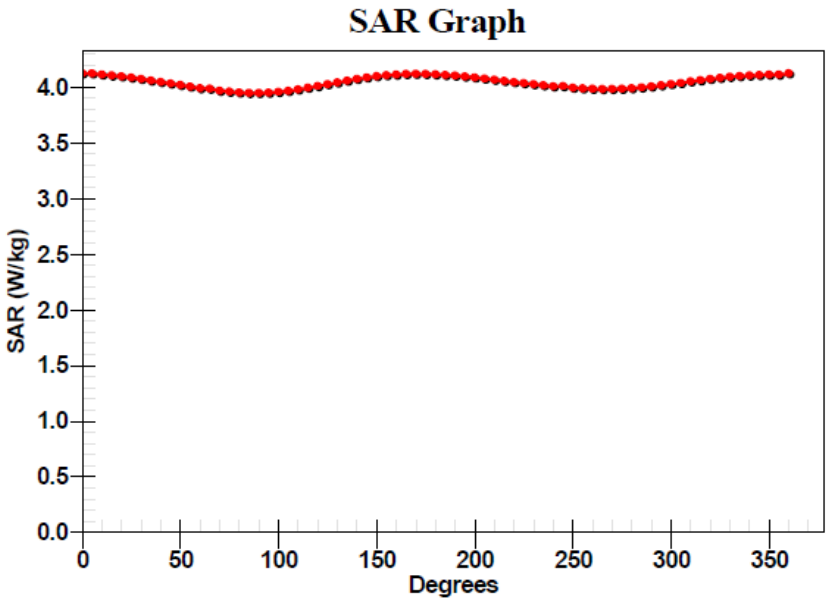
Isotropy Error Air



Isotropy SAR



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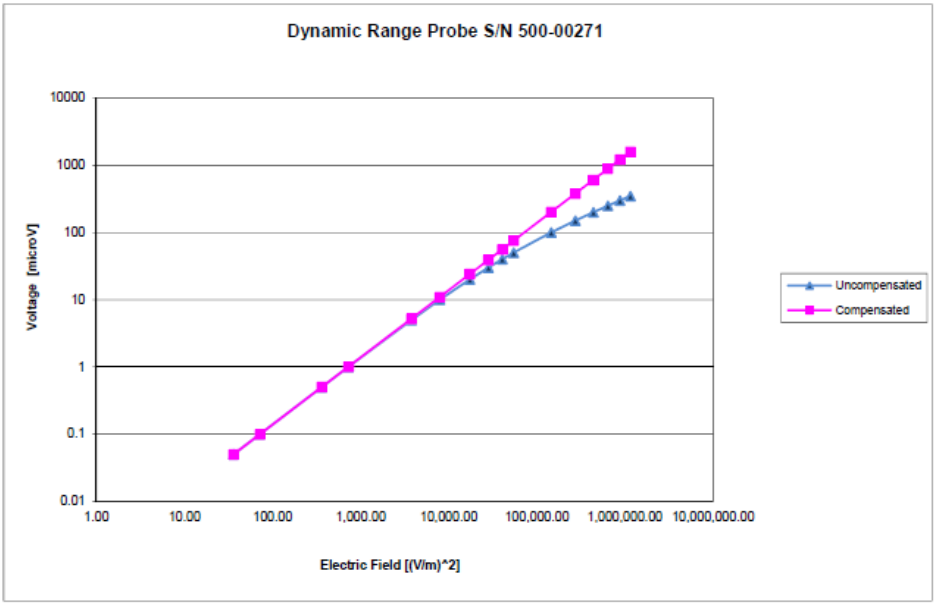
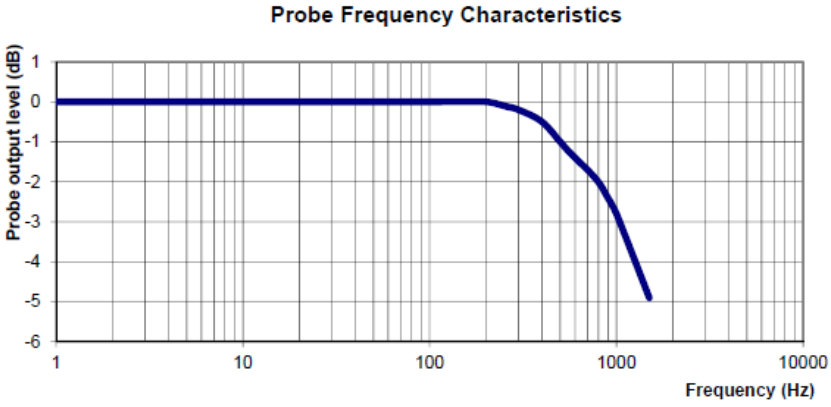
Dynamic Range



Video Bandwidth



Video Bandwidth at 500 Hz 1 dB
Video Bandwidth at 1.02 KHz: 3 dB

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E-2: Dipole antenna Calibration (450 MHz)

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1650
Project Number: Kostec-D-cal-5800

CERTIFICATE OF CALIBRATION

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.

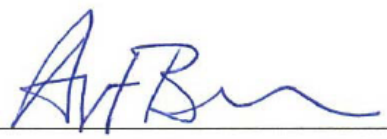
Validation Dipole (Head & Body)

Manufacturer: APREL Laboratories
Part number: ALS-D-450-S-2
Frequency: 450 MHz
Serial No: 175-00504

Customer: Kostec Co. Ltd.

Calibrated: 28th August 2015
Released on: 31st August 2015

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

Released By: 

Art Brennan, Quality Manager

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NCL Calibration Laboratories
Division of APREL Laboratories.

Conditions

Dipole 175-00504 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	Apr. 2, 2017
Network Analyzer Anritsu 37347C	002106	Feb. 4, 2017
Agilent Signal Generator	MY45094463	Dec.11, 2015

This page has been reviewed for content and attested to by signature within this document

NCL Calibration Laboratories
Division of APREL Laboratories.

Calibration Results Summary

The following results relate the Calibrated Dipole S/N **175-00504** and should be used as a quick reference for the user.

Mechanical Dimensions

Length	Height
298.0 mm	166.7 mm

Electrical Specification 450 MHz

Tissue Type	Return Loss:	Impedance:	SWR:
Head	-27.351 dB	51.469 Ω	1.106 U
Body	-28.473 dB	47.923 Ω	1.104 U

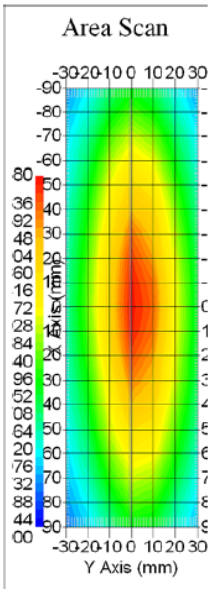
System Validation Results

Tissue Type	Frequency	1 Gram SAR	10 Gram SAR
Head	450 MHz	4.65	3.047
Body	450 MHz	4.43	2.997

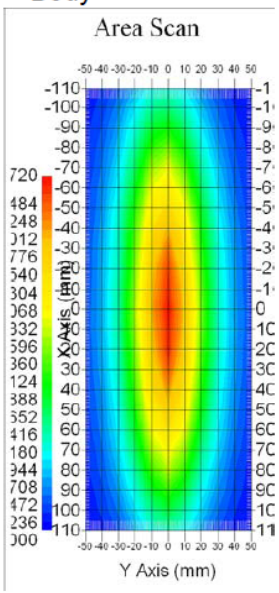
Tissue Type	Measured Epsilon (permittivity)	Measured Sigma (conductivity)
Head	45.58	0.896
Body	56.15	0.9

835MHz

Head



Body



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NCL Calibration Laboratories
Division of APREL Laboratories.

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 **175-00504**. 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 and Flat Phantom

References

- SSI-TP-018-ALSAS Dipole Calibration Procedure
- SSI-TP-016 Tissue Calibration Procedure
- IEEE 1528:2013 "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 radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures"
- Part 1: "Procedure to determine the Specific Absorption Rate (SAR) for hand-held devices used in close proximity of the ear (frequency range of 300 MHz to 3 GHz)"
- IEC-62209-2:2010 "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures"
- Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for hand-held devices used in close proximity of the ear (frequency range of 30 MHz to 6 GHz)"
- D28-002 Procedure for validation of SAR system using a dipole

Conditions

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

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%
TOTAL	**8.32% (16.64% K=2)**

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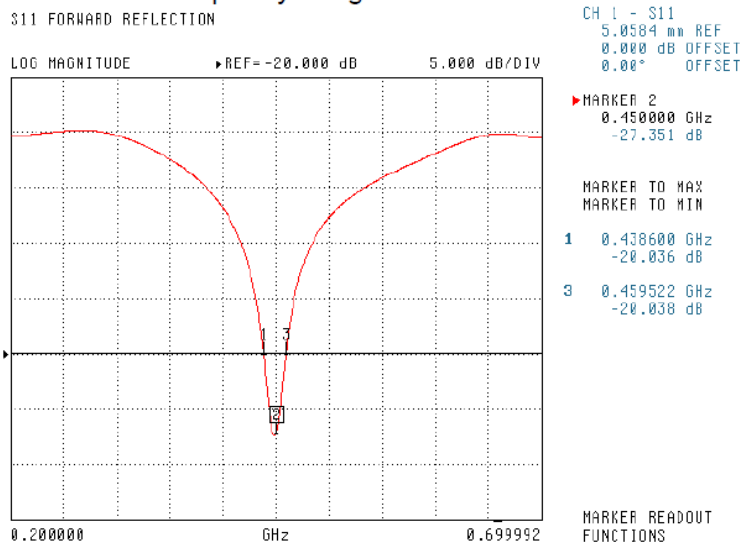
Electrical Calibration

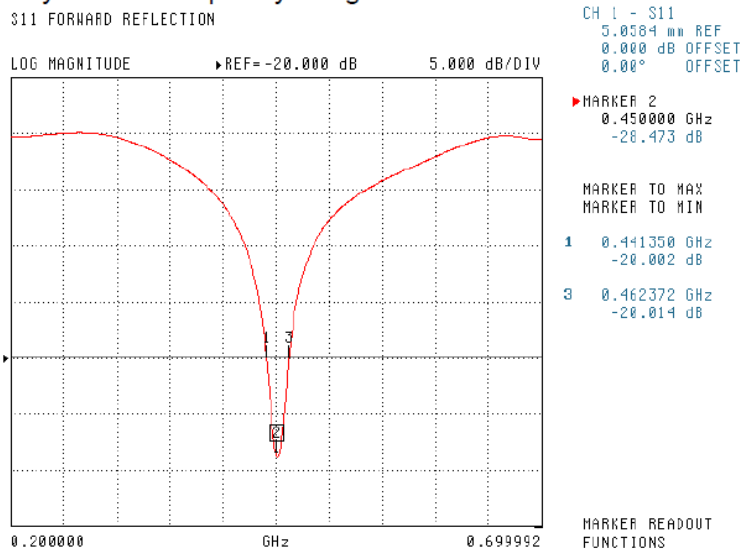
Electrical Specification 450 MHz

Forward Reflection

Head Tissue: Frequency Range 0.438 GHz to 0.460 GHz



Body Tissue: Frequency Range 0.441 GHz to 0.462 GHz



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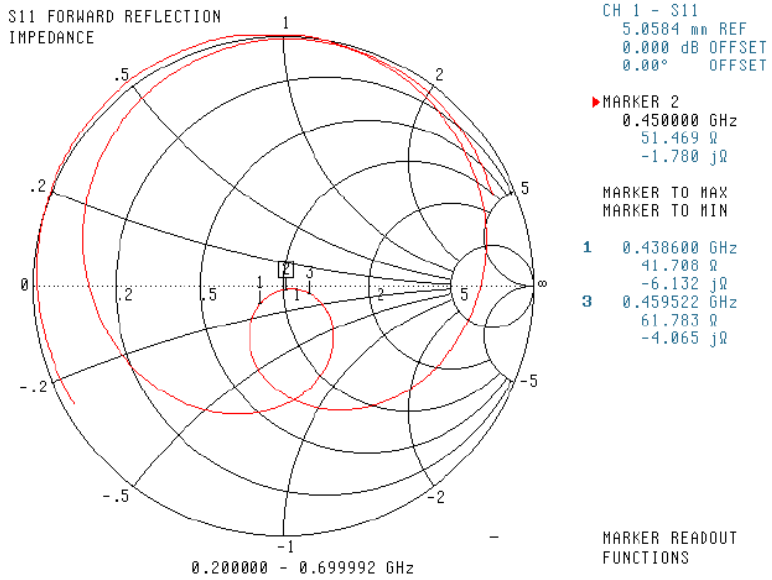
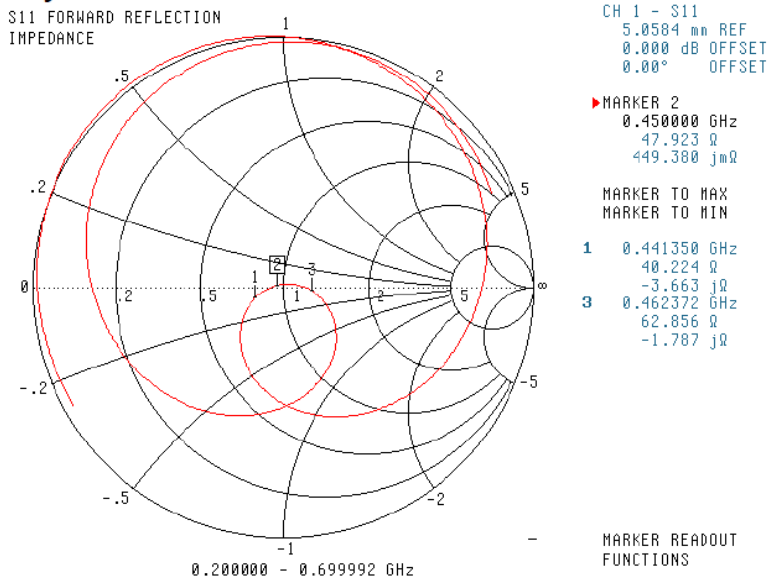
Electrical Specification 450 MHz

Impedance

Head Tissue



Body Tissue



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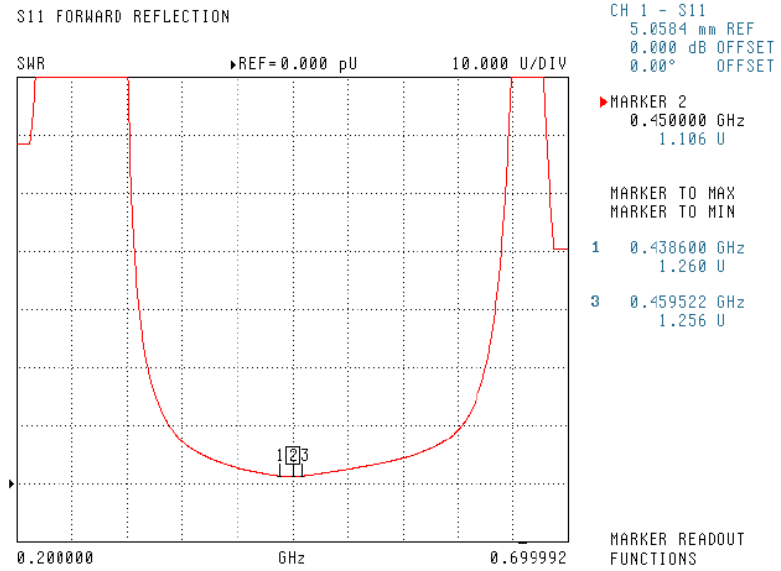
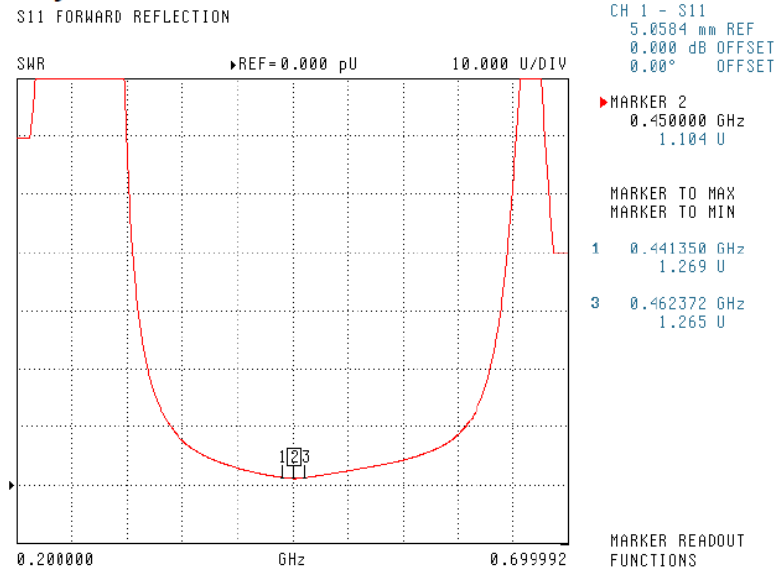
Electrical Specification 450 MHz
Standing Wave Ratio

Head Tissue



Body Tissue



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