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FCC SAR TEST REPORT

Report No: KST-FCS-140001

Applicant	:	Bluebird Inc.
Manufacturer	:	Bluebird Inc.
Equipment	:	Handheld PDA
Brand Name	:	-
Model Name	:	BM180
Standard	:	KDB 248227 SAR measurements for 802.11a/b/g KDB 447498 Mobile & Portable Devices RF Exposure KDB 865664 SAR Measurement 100 ㎒ to 6 ㎓
Test Date(s)	:	2014.02.12 - 2014.02.21
Issue Date	:	2014.02.24
Test Result	:	Compliance
Note	:	Request for various model names derived from the name of the base model by manufacturer. derived additional model names: BP30

Supplementary Information

The measurements shown in this test report were found to be in accordance with the requirements given in each KDB Guidance Publications and Rule References and in accordance with the procedure given in standard IEEE 1528-2003.

The test results in this report apply exclusively to tested model / sample. Without written approval of KOSTEC Co., Ltd., the test report shall not be reproduced except in full.

Tested by	Mi Young, Lee / Engineer	Approved by	Gyeong Hyeon, Park / Manager
Signature		Signature	

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1. Statement of Compliance

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

Mode	Position	1g SAR [W/㎏]
802.11b	Body(5 ㎜ Gap)	0.474 W/㎏

This device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/㎏) specified in ANSI C95.1 – 1999 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Field, 3 ㎑ to 300 ㎓[2], ANSI C95.3 – 2002 Recommended Practice for the measurement of Potentially Hazardous Electromagnetic Field [3], 47 C.F.R. § 2.1093, IEEE Standard 1528 – 2003.

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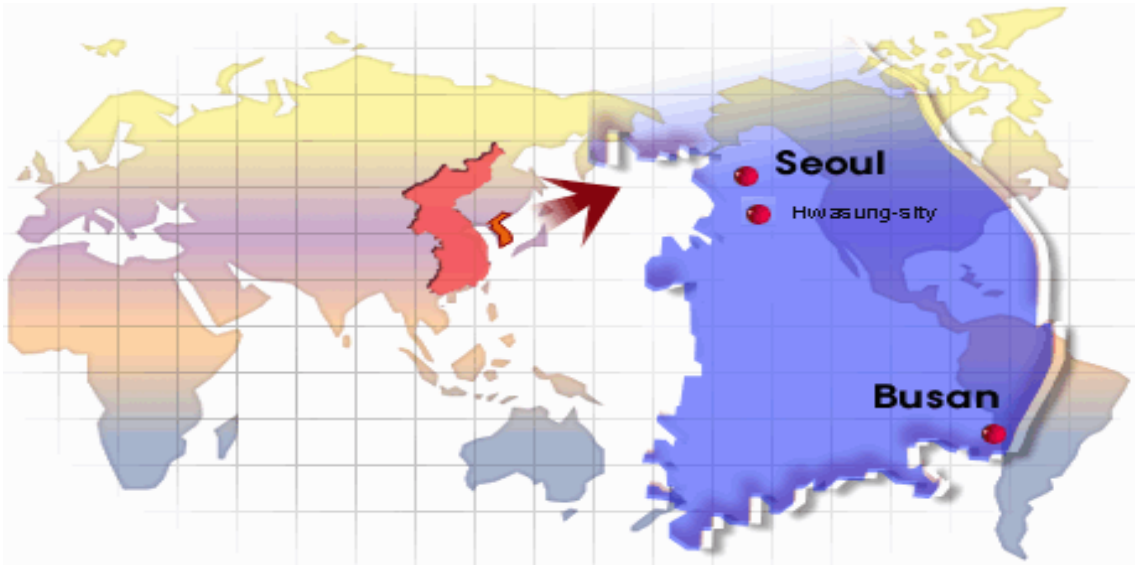
2. Administration Data

2.1 Test Laboratory

KOSTEC Co., Ltd.
180-254, Annyeong-dong, Hwaseong-si, Gyeonggi-do, South Korea

2.2 Location



2.3 Applicant

Bluebird Inc.
(Dogok-dong, SEI Tower 13,14) 39, Eonjuro30-gil, Gangnam-gu, Seoul, South Korea

2.4 Manufacturer

Bluebird Inc.
(Dogok-dong, SEI Tower 13,14) 39, Eonjuro30-gil, Gangnam-gu, Seoul, South Korea

2.5 Application Details

Date of Receipt of application : 2014.02.06
Date of Start during the test : 2014.02.12
Date of End during the test : 2014.02.21

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3. GENERAL INFORMATION

3.1 Description of DUT

DUT Type	Handheld PDA
Brand Name	None
Model Name	BM180
Modulation Type	802.11b: DSSS (DBPSK / DQPSK / CCK) 802.11a/g/n: OFDM (BPSK / QPSK / 16QAM / 64QAM) Bluetooth 2.1 BDR (1Mbps) : GFSK Bluetooth 2.1 EDR (2Mbps) : π/4-DQPSK Bluetooth 2.1 EDR (3Mbps) : 8-DPSK Bluetooth 4.0 LE: GFSK
Frequency Range	802.11b/g: 2412 ㎒ - 2462 ㎒ 802.11a: 5180 ㎒ - 5240 ㎒ (UNII Band I) 5260 ㎒ - 5320 ㎒ (UNII Band II) 5500 ㎒ - 5700 ㎒ (UNII Band III) 5745 ㎒ - 5825 ㎒ (UNII Band IV) 802.11n(HT20): 2412 ㎒ - 2462 ㎒ 5180 ㎒ – 5240 ㎒ (UNII Band I) 5260 ㎒ - 5320 ㎒ (UNII Band II) 5500 ㎒ - 5700 ㎒ (UNII Band III) 5745 ㎒ - 5825 ㎒ (UNII Band IV) 802.11n(HT40): 5190 ㎒ - 5230 ㎒ (UNII Band I) 5270 ㎒ - 5310 ㎒ (UNII Band II) 5510 ㎒ - 5670 ㎒ (UNII Band III) 5755 ㎒ - 5795 ㎒ (UNII Band IV) Bluetooth: 2402 ㎒ - 2480 ㎒ NFC: 13.56 ㎒
Operating mode	For WLAN SAR testing, WLAN engineering testing software installed on the EUT can provide continuous transmitting RF signal.
Antenna Specification	Type : Internal PCB Antenna Max.gain: 2.87 ㏈i (2 ㎓ band), 0.56 ㏈i(5 ㎓ band)
Max. Output power(conducted)	22.81 ㏈m
Max.SAR(10 g)	0.474 W/㎏
Remark	- Voice call is not supported. - The data rates used when evaluating the WiFi transmitter were the lowest data rates for each mode. The device was operating at its maximum output power at the lowest data rate for all measurements. - The test utility for WLAN is GRCT. - The above DUT's information was declared by manufacturer. Please refer to the specifications or user manual for more detailed description.
FCC ID	SS4-PW8Q7A

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- The DUT conducted power(dBm) listed as below,

WLAN

802.11b			
Channel	1	6	11
Freq	2412	2437	2462
1Mbps	14.03	14.20	13.89
2Mbps	13.98	14.18	13.84
5.5Mbps	13.73	13.89	13.63
11Mbps	13.41	13.58	13.24
802.11g			
Channel	1	6	11
Freq	2412	2437	2462
6Mbps	13.62	13.87	13.33
9Mbps	13.37	13.59	13.03
12Mbps	13.17	13.36	12.80
18Mbps	12.75	12.82	12.35
24Mbps	12.36	12.43	11.89
36Mbps	11.74	11.83	11.32
48Mbps	11.18	11.30	10.77
54Mbps	10.98	11.09	10.57
802.11n(HT20)			
Channel	1	6	11
Freq	2412	2437	2462
MCS0	13.72	13.80	13.54
MCS1	13.24	13.35	13.05
MCS2	12.81	12.94	12.67
MCS3	12.41	12.54	12.21
MCS4	11.79	11.97	11.66
MCS5	11.21	11.55	11.22
MCS6	10.98	11.30	11.01
MCS7	10.76	11.10	10.83
802.11a (UNII band I)			
Channel	36	44	48
Freq	5180	5220	5240
6Mbps	14.92	14.46	14.68
9Mbps	14.79	14.41	14.74
12Mbps	14.87	14.42	14.61
18Mbps	14.84	14.49	14.69
24Mbps	14.81	14.42	14.75
36Mbps	14.91	14.56	14.63
48Mbps	14.75	14.60	14.67
54Mbps	14.84	14.68	14.88
802.11n(HT20) (UNII band I)			
Channel	36	44	48
Freq	5180	5220	5240
MCS0	14.98	14.55	14.74
MCS1	14.96	14.62	14.78
MCS2	14.94	14.63	14.85
MCS3	14.90	14.53	14.74
MCS4	14.75	14.51	14.68
MCS5	14.80	14.52	14.70
MCS6	14.79	14.55	14.68
MCS7	14.76	14.39	14.58

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802.11n(HT40) (UNII band I)			
Channel	38	46	
Freq	5190	5230	
MCS0	11.99	14.73	
MCS1	11.79	14.53	
MCS2	11.87	14.35	
MCS3	11.36	14.36	
MCS4	11.24	14.62	
MCS5	11.57	14.37	
MCS6	11.39	14.14	
MCS7	11.16	14.05	
802.11a (UNII band II)			
Channel	52	60	64
Freq	5260	5300	5320
6Mbps	16.67	16.88	15.85
9Mbps	16.74	16.83	15.52
12Mbps	16.52	16.72	15.69
18Mbps	16.61	16.73	15.64
24Mbps	16.67	16.73	15.76
36Mbps	15.79	15.81	15.64
48Mbps	15.73	15.72	15.76
54Mbps	16.32	16.26	15.66
802.11n(HT20) (UNII band II)			
Channel	52	60	64
Freq	5260	5300	5320
MCS0	16.81	16.71	15.80
MCS1	16.79	16.77	15.79
MCS2	16.79	16.74	15.62
MCS3	16.69	16.74	15.53
MCS4	16.71	16.66	15.51
MCS5	16.03	15.98	15.60
MCS6	16.04	15.96	15.54
MCS7	14.89	14.60	15.56
802.11n(HT40) (UNII band II)			
Channel	54	62	
Freq	5270	5310	
MCS0	17.23	12.71	
MCS1	17.20	12.98	
MCS2	17.22	12.76	
MCS3	16.13	12.87	
MCS4	16.20	12.64	
MCS5	16.18	12.82	
MCS6	15.97	12.80	
MCS7	14.93	12.82	
802.11a (UNII band III)			
Channel	100	116	140
Freq	5500	5580	5700
6Mbps	16.87	16.54	15.50
9Mbps	16.75	16.57	15.39
12Mbps	16.71	16.52	15.32
18Mbps	16.69	16.53	15.41
24Mbps	16.56	16.52	15.28
36Mbps	15.79	15.75	15.15
48Mbps	15.72	15.57	15.27
54Mbps	16.09	15.81	15.29

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802.11n(HT20) (UNII band III)			
Channel	100	116	140
Freq	5500	5580	5700
MCS0	16.89	16.46	14.47
MCS1	16.87	16.60	14.25
MCS2	16.72	16.63	14.24
MCS3	16.62	16.38	13.86
MCS4	16.88	16.61	14.07
MCS5	16.31	16.27	14.16
MCS6	15.87	15.72	14.04
MCS7	14.66	14.51	14.19
802.11n(HT40) (UNII band III)			
Channel	102	110	134
Freq	5510	5550	5670
MCS0	13.68	17.19	17.37
MCS1	13.37	17.07	17.31
MCS2	13.44	17.22	17.35
MCS3	13.36	16.74	17.32
MCS4	13.20	16.66	17.22
MCS5	13.59	15.81	15.84
MCS6	13.26	15.50	15.80
MCS7	13.21	14.58	14.81
802.11a (UNII band IV)			
Channel	149	157	165
Freq	5745	5785	5825
6Mbps	22.29	21.64	22.81
9Mbps	22.31	21.61	22.77
12Mbps	22.33	21.66	22.76
18Mbps	22.19	21.62	22.80
24Mbps	22.19	21.65	22.78
36Mbps	22.22	21.61	22.73
48Mbps	22.27	21.67	22.71
54Mbps	21.85	21.44	22.51
802.11n(HT20) (UNII band IV)			
Channel	149	157	165
Freq	5745	5785	5825
MCS0	22.37	21.68	22.79
MCS1	22.34	21.62	22.72
MCS2	22.29	21.63	22.68
MCS3	22.17	21.65	22.78
MCS4	22.08	21.61	22.73
MCS5	22.02	21.67	22.71
MCS6	21.99	21.61	22.62
MCS7	21.81	21.57	22.69
802.11n(HT40) (UNII band IV)			
Channel	151	159	
Freq	5755	5795	
MCS0	22.20	22.14	
MCS1	22.11	22.01	
MCS2	22.07	22.03	
MCS3	22.02	21.92	
MCS4	22.09	22.00	
MCS5	22.10	21.99	
MCS6	22.01	21.88	
MCS7	21.75	21.52	

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BT BDR, EDR

Channel	0	39	78
Freq	2402	2441	2480
BDR(GFSK)	6.85	6.48	6.74
EDR(π/4-DQPSK)	7.59	7.11	7.38
EDR(8DPSK)	7.95	7.43	7.70

BT LE

Channel	0	19	39
Freq	2402	2440	2480
LE(GFSK)	1.79	1.36	1.46

Note:
1. Per KDB 248227 D01 V01r02, choose the highest output power channel to test SAR and determine further SAR exclusion.
2. Per KDB 248227 D01 v01r02, 11g, 11n(HT20) output power is less than 1/4 dB higher than 11b mode, thus the SAR can be excluded.
3. Per KDB 248227 D01 v01r02, 11n(HT20) in 5 GHz output power is less than 1/4 dB higher than 11a mode, thus the SAR can be excluded.
4. For each frequency band, testing at higher data rates and higher order modulations is not required when the maximum average output power for each of these configurations is less than 1/4 dB higher than those measured at the lowest data rate.
5. Bluetooth operation was not evaluated as the power level of the BT transmitter was less than 10 mW per KDB 447498 Appendix A. The Bluetooth transmitter does not simultaneously transmit with the WiFi transmitter.

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3.2 Photographs of EUT

Front

Rear

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Top

Bottom

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Left

Right

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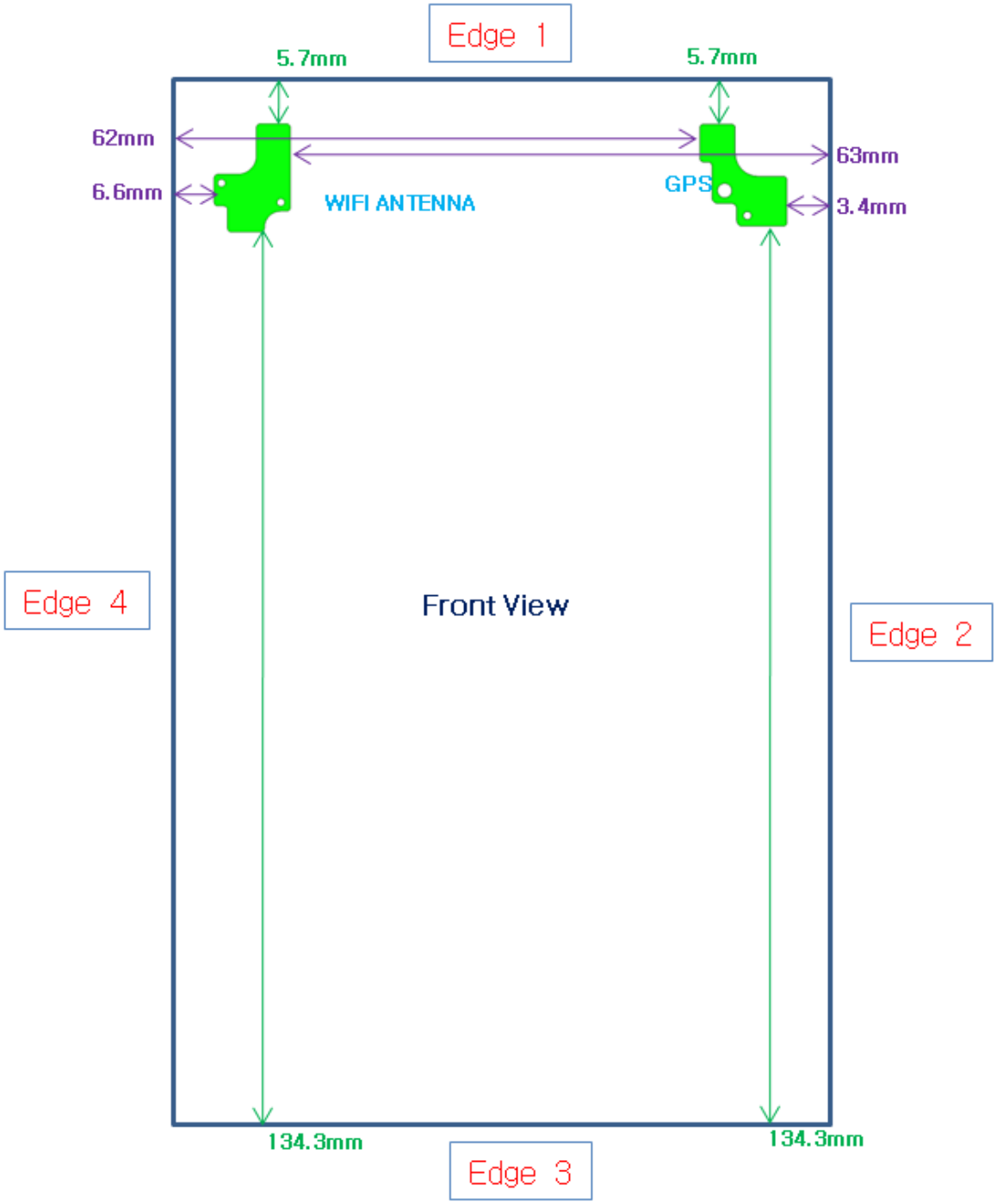
3.3 Exposure Positions Consideration



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Note:

1. Maximum power is the source-based time-average power and represents the maximum RF output power among production units.
2. Per KDB 447498 D01v05r02, for larger devices, the test separation distance is determined by the closest separation between the antenna and the user.
3. Per KDB 447498 D01v05r02, standalone SAR test exclusion threshold is applied; If the distance of the antenna to the user is < 5 ㎜, 5 ㎜ is used to determine SAR exclusion threshold
4. Per KDB 447498 D01v05r02, the 1-g and 10-g SAR test exclusion thresholds for 100 ㎒ to 6 ㎓ at test separation distances ≤ 50 ㎜ are determined by:

   [(max. power of channel, including tune-up tolerance, ㎽)/(min. test separation distance, ㎜)] ·[√f(㎓)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR

   - f(㎓) is the RF channel transmit frequency in ㎓
   - Power and distance are rounded to the nearest ㎽ and ㎜ before calculation
   - The result is rounded to one decimal place for comparison
5. Per KDB 447498 D01v05r02, at 100 ㎒ to 6 ㎓ and for test separation distances > 50 ㎜, the SAR test exclusion threshold is determined according to the following

   a) [Threshold at 50 ㎜ in step 1) + (test separation distance - 50 ㎜)·(f(MHz)/150)] ㎽, at 100 ㎒ to 1500 ㎒
   b) [Threshold at 50 ㎜ in step 1) + (test separation distance - 50 ㎜)·10] ㎽ at > 1500 ㎒ and ≤ 6 ㎓

Thus, Edge 2 and 3 are not tested.

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3.4 Test Condition

3.4.1 Ambient Condition

• Ambient temperature : (20 - 21) ℃

• Relative Humidity : (30 – 35) % R.H.

3.4.2 Test Configuration

For WLAN SAR testing, WLAN engineering testing software installed on the EUT can provide continuous transmitting RF signal.

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 ㎽/g for an uncontrolled environment and 8.0 ㎽/g for an occupational/controlled environment as recommended by the ANSI/IEEE standard C95.1-1992 [6].

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.

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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:

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

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

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

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

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

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

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 $㎟$) 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 1 $㎣$)

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5. SAR Measurement System

[ALSAS-10U System Description]

The CRS F3 robot is a 6 axis articulated robot with a reach of 710 ㎜ and a maximum speed of 1016 ㎜/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 +/- .05 ㎜. 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.

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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 ㎒ to 6 ㎓ with the probe diameter scientifically verified for use at frequencies above 3 ㎓ 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 ㎜ 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 ㎜ 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 ㎒~ 6 ㎓
Sensitivity	0.60 ㎶/(V/m)^2 to1.25 ㎶/(V/m)^2
Dynamic Range SAR	0.001 W/㎏ to 100 W/㎏
Isotropic Response Axial	Better than 0.2 ㏈ in air Better than 0.05 ㏈ in tissue
Hemispherical isotropy	±0.3 ㏈ or better
Diode Compression Point (DCP)	Calibrated for Specific Frequency typically 95 ㎷ +/- 10 %
Linearity	±0.2 ㏈ or better
Probe Tip Radius	<2.9 ㎜
Sensor Offset	1.56 (± 0.02 ㎜)
Probe Length	290 ㎜
Video Bandwidth	@ 500 Hz: 1 ㏈ @ 1K Hz: 3 ㏈
Boundary Effect	Less than 2 % for distances greater than 1.4mm
Material	Ertalyte™
Connector	6 Pin Bayonet
Probe Diameter	Less than 2.8 ㎜

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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 ㎜
Translation Along NF Line	± 38.1 ㎜
Translation Along Z Axis	± 25.4 ㎜ (expandable up to 500 ㎜)
Rotation Around MB Line (yaw)	±10°
Rotation Around NF (pitch)	± 30°
Line Rotation (roll)	360° full circle
Maximum Grip Range	0 ㎜ to 150 ㎜
Material	Resistant to DGBE and all other tissue stimulant materials
Tilt Movement	Full movement with built-in 15° gauge

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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 ㎜.

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 ㎜
Translation Along NF Line	± 38.1 ㎜
Translation Along Z Axis	± 25.4 ㎜ (expandable up to 500 ㎜)
Rotation Around MB Line (yaw)	±10°
Rotation Around NF (pitch)	± 30°
Line Rotation (roll)	360° full circle
Maximum Grip Range	0 ㎜ to 150 ㎜
Material	Resistant to DGBE and all other tissue stimulant materials
Tilt Movement	Full movement with built-in 15° gauge

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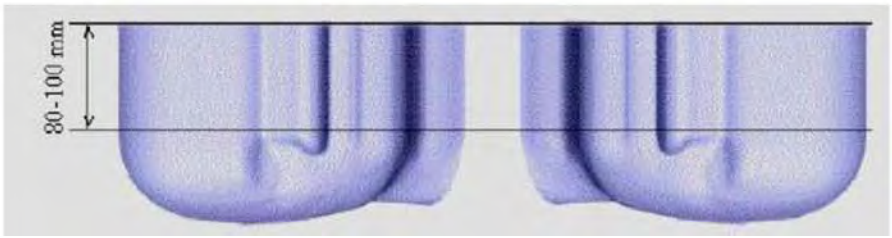
5.4 SAM Phantoms

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 ㎜
Frame Material	Corian®
Tissue Simulation Volume	7 liter with 15.0 ±0.5 ㎝ tissue
Thickness	2 ㎜ ±0.2 ㎜ 6 ㎜ ±0.2 ㎜ 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	<1mm with sugar water compositions
Manufacturing Process	Injection Molded
Phantom Weight	Less than 10 ㎏ when filled with 15cm of simulation tissue

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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 ㎒ to 6 ㎓. 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 ㎜
Operating Frequency Range	30 ㎒ – 6 ㎓
Tissue Simulation Volume	12.8 liter with a liquid depth of 150 ㎜
Shell Thickness	2 ㎜ ±0.2 ㎜
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 ㎜
Dimensions without frame	340 ㎜x 270 ㎜ x 225 ㎜

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 ㎜

-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 ㎏.

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

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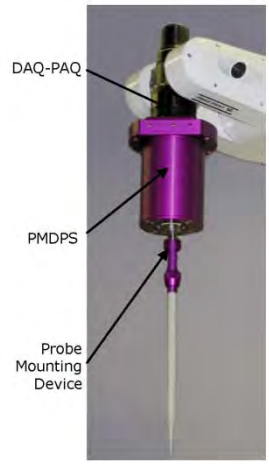
5.6 DAQ-PAQ (Analog to Digital Electronics)



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 ㎶ to 330 ㎷. 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 1㎛.

Amplifier Range	4 ㎶ to 330 ㎷
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/㎏ -100 W/㎏.
Ambient Noise	Below 0.001 W/㎏ 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 ㎛ at 6 ㎓.
- SAR Uncertainty: Better than 0.01 W/㎏ SAR at 6 ㎓.
- Detection Mechanism: 2 x 360° Stage Axial and Lateral Detection at 6 ㎓.
- Emergency Stop: 4 Stage 360° Axial and Lateral Detection at 6 ㎓.
- Probe Mounting: 6 Pin Bayonet for Fast Probe Change.
- Calibration: Every PMDPS is Calibrated to 0.01 W/㎏ SAR at 6 ㎓.

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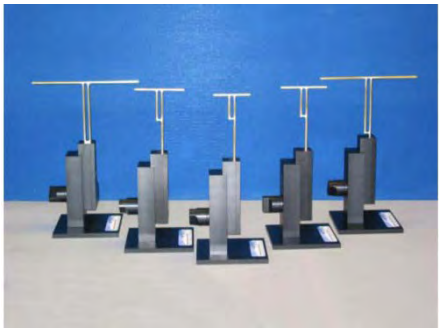
5.7 Validation Dipoles



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	> -20 dBm
Max Power Input	100 Watt

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5.8 Test Equipment List

No.	Instrument	Manufacturer	Model	S/N	Due to cal date	used
1	The Teach Pedant	Thermo ELECTRON CORPORATION	STP 500	STP0502506	N/A	☒
2	Universal Phantom	APREL Laboratories	ALS-P-UP-1	None	N/A	☐
3	Left Ear SAM Phantom	APREL Laboratories	ALS-P-SAM-L	130-00316	N/A	☐
4	Right Ear SAM Phantom	APREL Laboratories	ALS-P-SAM-R	140-00367	N/A	☐
5	6 Axis Articulated Robot	Thermo CRS	ALS-F3	RAF0504263	N/A	☒
6	ROBOTS CONTROLLER	Thermo CRS	UMI-R3-310	RCF0503290	N/A	☒
7	Data Acquisition Package	APREL Laboratories	ALS-DAQ-PAQ-3	110-00204	N/A	☒
8	Probe Mounting Device and Boundary Detection Sensor System	APREL Laboratories	ALS-PMDPS-3	120-00269	N/A	☒
9	Device Holder	APREL Laboratories	ALS-H-E-SET-2	170-00507	N/A	☒
10	Reference Dipole	APREL Laboratories	ALS-D-450-S-2	175-00504	2015.02.27	☐
11	Reference Dipole	APREL Laboratories	ALS-D-835-S-2	180-00555	2015.02.14	☐
12	Reference Dipole	APREL Laboratories	ALS-D-1800-S-2	200-00656	2015.02.14	☐
13	Reference Dipole	APREL Laboratories	ALS-D-1900-S-2	210-00717	2015.02.27	☐
14	Reference Dipole	APREL Laboratories	ALS-D-2000-S-2	212-00830	2015.02.14	☐
15	Reference Dipole	APREL Laboratories	ALS-D-2450-S-2	220-00764	2015.02.27	☒
16	Reference Dipole	APREL Laboratories	ALS-D-BB-S-2	235-00807	2015.02.27	☒
17	Miniature E-Field Probe	APREL Laboratories	ALS-E-020	271	2014.07.02	☒
18	Miniature E-Field Probe	APREL Laboratories	ALS-DR	028	N/A	☐
19	Di-Electric Probe	APREL Laboratories	ALS-PR-DIEL	260-00961	N/A [Note1]	☒
20	Lowpass filter	WAINWRIGHT INSTRUMNENTS GMBH	WLJS1000-6EF	1	2015.02.07	☐
21	Lowpass filter	WAINWRIGHT INSTRUMNENTS GMBH	WLJS2500-6EF	1	2015.02.07	☒
22	Dual directional coupler	HEWLETT PACKARD	778D	17693	2015.02.07	☐
23	Dual directional coupler	HEWLETT PACKARD	772D	2839A00924	2015.02.07	☒
24	3.5 ㎜ Cal. Kit	Agilent Technologies	85033D	3423A07123	N/A	☒
25	3 dB Attenuator	Agilent Technology	8491B	MY39263672	2015.02.07	☒
26	EPM Series Power meter	Agilent Technology	E4418B	MY41293610	2015.02.07	☒
27	Power sensor	Agilent Technology	E9300A	MY41496666	2015.02.07	☒
28	RF Amplifier	Sungsan Electronics Communications	SSA024	SSEC0001	2015.02.07	☒
29	Hot plate & Magnetic stirrer	Misung Elec.	HS33	None	N/A	☐
30	Stirrer	Misung Elec.	BL1003D	None	N/A	☐
31	Electric balance	CAS	SW-30H	CLA1675	2015.02.07	☐
32	Electric balance	SHENZHEN ACCT	KB-500	KB031419	2015.02.07	☐
33	Di-water machine	HYSC	HWS-FA12	XM0015576	N/A	☐
34	Digital Hygrometer	ACUBA	CS-102	1211	2015.02.10	☒
35	Flat Phantom	APREL Laboratories	ALS-UM-FLAT	153-00102	N/A	☒
36	Digital thermo-hgrometer	SATO	PC-5000TRH-II	1	2014.08.08	☒
37	Digital thermo-hgrometer	SATO	PC-5000TRH-II	2	2014.08.08	☒
38	EPM Series Power meter	Agilent Technology	E4418B	GB39512547	2015.02.07	☒
39	Power Sensor	Agilent Technology	E9300A	MY41496631	2015.02.07	☒

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No.	Instrument	Manufacturer	Model	S/N	Due to cal date	used
40	Radio Communication Analyzer	ANRITSU	MT8815A	6200429622	2015.02.07	☐
41	CDMA Mobile Station Test Set	AGILENT	E8285A	US40081298	2015.02.07	☐
42	Attenuator	HP	8498A	3318A09485	2015.02.07	☒
43	Signal Generator	ROHDE&SCHWARZ	SMT-06	100552	2015.02.07	☒
44	Highpass Filter	WAINWRIGHT INSTRUMNENTS GMBH	WHJS3000-10EF	1	2015.02.07	☒
45	Network Analyzer	Agilent	8753ES	US39170869	2014.10.05	☒
46	Vernier Calipers	Mitutoyo	None	8280373	2014.10.05	☒

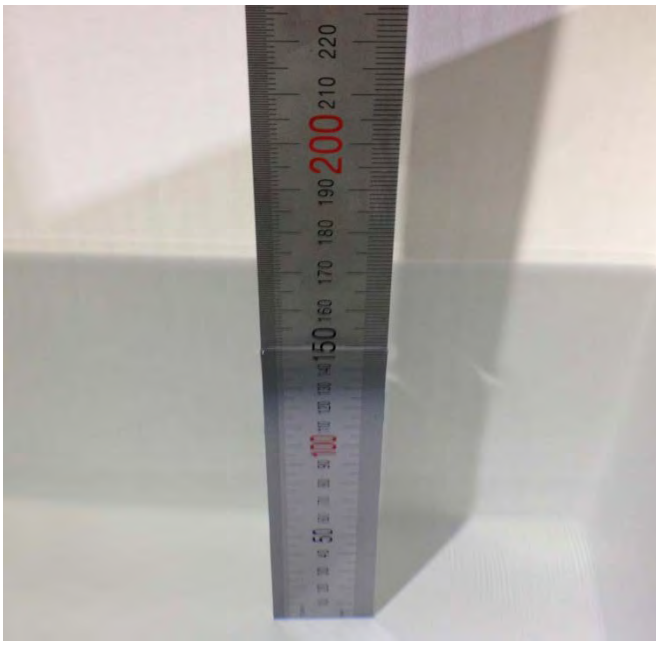
Note 1: The dielectric probe was calibrated via the network analyzer, with the specified procedure (calibrated in pure water) and calibration (standard) short circuit, before the dielectric measurement. Also the dielectric probe was calibrated by APREL.

6. Measurement Results

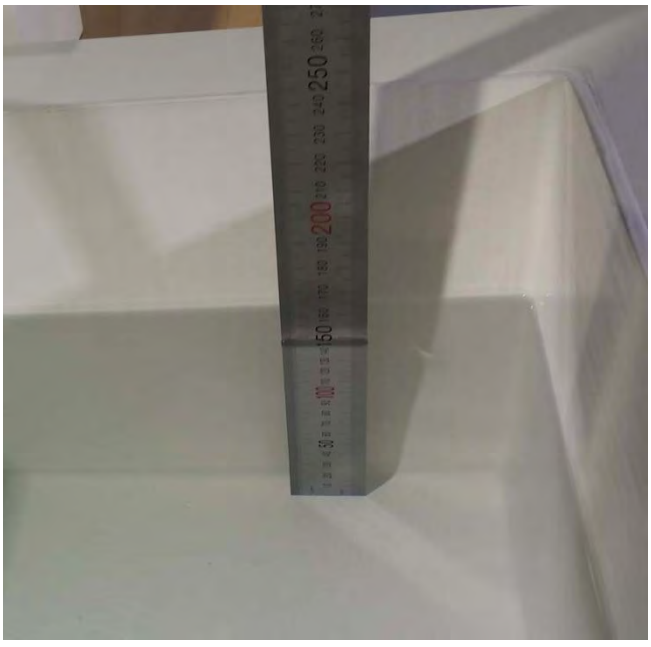
6.1 Tissue Simulating Liquids

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



[Photo of liquid height for 2 ㎓ SAR testing]



[Photo of liquid height for 5 ㎓ SAR testing]

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6.1.1 Recipes for tissue simulating liquid.

Freq. (MHz)	DI water (%)	Salt (%)	DGBE (%)	DGMHE (%)	Triton X100	Total (%)
2 450	53.30	-	46.70	-	-	100
5 200 ~ 5 800	76.45	-	-	4.77	18.78	100

6.1.2 Measuring result for simulating liquid

Liquid		Parameters	Target	Measured	Deviation	Limit	Date
Freq. (MHz)	Temp. (°C)						
2 450	21	Permitivity	52.7	52.33	0.71	±5	2014.02.12
		Conductivity	1.95	2.02	3.50	±5	
5 200	21	Permitivity	48.90	50.19	2.64	±5	2014.02.20
		Conductivity	5.35	5.34	0.19	±5	
5 400	21	Permitivity	48.65	49.49	1.73	±5	
		Conductivity	5.35	5.56	3.93	±5	
5 600	21	Permitivity	48.40	49.97	3.24	±5	2014.02.21
		Conductivity	5.78	5.86	1.38	±5	
5 800	21	Permitivity	48.20	49.60	2.90	±5	
		Conductivity	6.00	6.09	1.50	±5	

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

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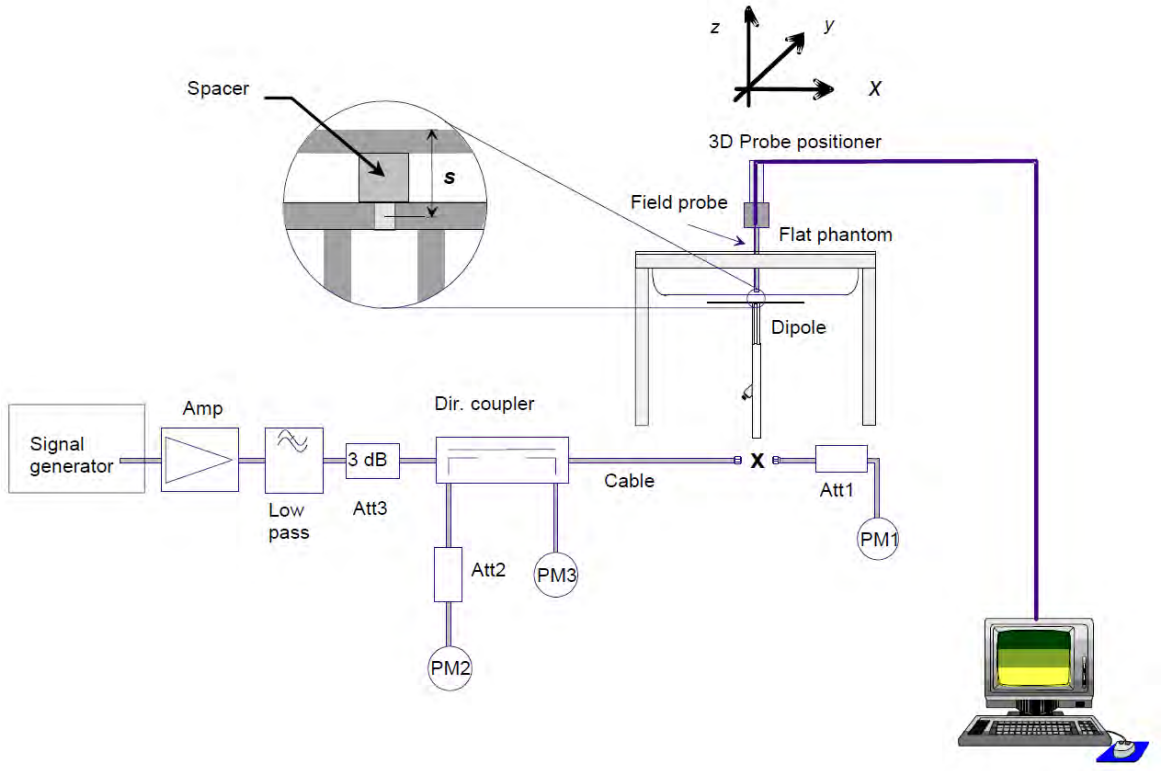
6.2 System Verification

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 ㎽ RF dipole input power was used. The 1g and 10 g spatial average SAR values normalized to 1 W dipole input power give reference data for comparisons and it's equal to 10x(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 validation]

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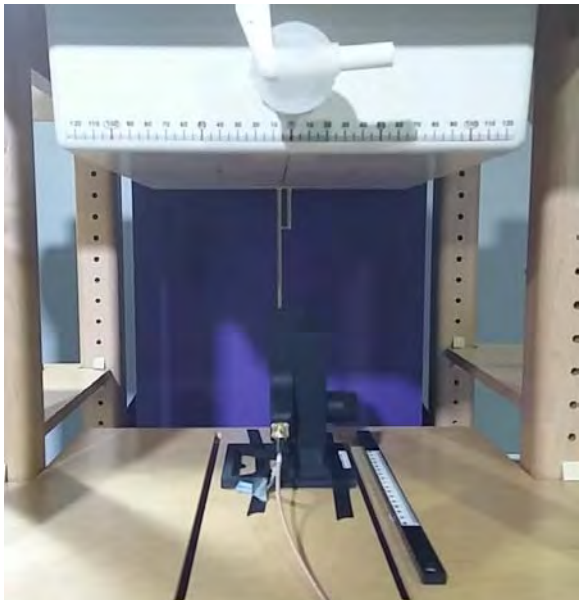

[Photo of dipole setup for 2 ㎓]

[Photo of dipole setup for 5 ㎓]

6.2.3 Verification Results

Date	Frequency (㎒)	Measured SAR (W/kg)	Normalized SAR (W/kg)	Target SAR (W/kg)	Devation (%)
2014.02.12	2 450	5.374	53.74	49.8	7.91
2014.02.20	5 200	6.286	62.86	65.2	3.59
2014.02.20	5 400	6.407	64.07	62.1	3.17
2014.02.21	5 600	6.701	67.01	66.8	0.31
2014.02.21	5 800	6.533	65.33	60.4	8.16

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 validation 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,

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

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

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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 ㎟) 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 ㎟).

6.5 SAR Exposure Limits

SAR assessments have been made in line with the requirements of IEEE-1528, the applicable KDB publications by the FCC , and comply with ANSI/IEEE C95.1-1992 “Uncontrolled Environments” limits. These limits apply to a location which is deemed as “Uncontrolled Environment” which can be described as a situation where the general public may be exposed to an RF source with no prior knowledge or control over their exposure.

T ype of Exposure	SAR Limit(W/㎏)
Whole body	0.08
Head/Body	1.6
Hands, Wrists, Feet and Ankles	4.0

6.6 SAR test result

No	Mode	FREQ	CH	Test Position	Antenna	Drift(%)	Measured 1 g SAR (W/㎏)	Scaled 1 g SAR (W/㎏)	Scaling Factor
1	802.11b	2 437	CH6	FRONT	Internal	4.496	0.211	0.298	1.41
2	802.11b	2 437	CH6	REAR	Internal	4.497	0.060	0.085	1.41
3	802.11b	2 437	CH6	TOP	Internal	4.319	0.109	0.154	1.41
4	**802.11b**	**2 437**	**CH6**	**LEFT**	**Internal**	**4.260**	**0.336**	**0.474**	**1.41**
5	802.11a	5 220	CH44	FRONT	Internal	2.935	0.242	0.341	1.41
6	802.11a	5 220	CH44	REAR	Internal	1.016	0.291	0.410	1.41
7	802.11a	5 220	CH44	TOP	Internal	2.755	0.271	0.382	1.41
8	802.11a	5 220	CH44	LEFT	Internal	2.883	0.332	0.468	1.41
9	802.11a	5 300	CH60	FRONT	Internal	1.681	0.201	0.283	1.41
10	802.11a	5 300	CH60	REAR	Internal	2.314	0.245	0.345	1.41
11	802.11a	5 300	CH60	TOP	Internal	3.281	0.257	0.362	1.41
12	802.11a	5 300	CH60	LEFT	Internal	2.410	0.294	0.415	1.41
13	802.11n(HT40)	5 270	CH54	FRONT	Internal	2.261	0.210	0.296	1.41
14	802.11n(HT40)	5 270	CH54	REAR	Internal	1.005	0.262	0.369	1.41
15	802.11n(HT40)	5 270	CH54	TOP	Internal	3.240	0.312	0.440	1.41
16	802.11n(HT40)	5 270	CH54	LEFT	Internal	2.929	0.315	0.444	1.41

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No	Mode	FREQ	CH	Test Position	Antenna	Drift(%)	Measured 1 g SAR (W/Kg)	Scaled 1 g SAR (W/Kg)	Scaling Factor
17	802.11a	5 580	CH116	FRONT	Internal	2.889	0.244	0.344	1.41
18	802.11a	5 580	CH116	REAR	Internal	4.324	0.180	0.254	1.41
19	802.11a	5 580	CH116	TOP	Internal	0.439	0.202	0.285	1.41
20	802.11a	5 580	CH116	LEFT	Internal	1.945	0.283	0.399	1.41
21	802.11n(HT40)	5 550	CH110	FRONT	Internal	1.937	0.222	0.313	1.41
22	802.11n(HT40)	5 550	CH110	REAR	Internal	2.282	0.194	0.274	1.41
23	802.11n(HT40)	5 550	CH110	TOP	Internal	1.228	0.159	0.224	1.41
24	802.11n(HT40)	5 550	CH110	LEFT	Internal	1.168	0.189	0.266	1.41
25	802.11a	5 785	CH157	FRONT	Internal	1.882	0.162	0.228	1.41
26	802.11a	5 785	CH157	REAR	Internal	3.902	0.114	0.161	1.41
27	802.11a	5 785	CH157	TOP	Internal	4.651	0.207	0.292	1.41
28	802.11a	5 785	CH157	LEFT	Internal	4.078	0.218	0.307	1.41

Please see appendix for the SAR test plots.

Note:

1. Per KDB 447498 D01v05r02, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.

Scaling Factor = tune-up limit power (㎽) / EUT RF power (㎽), where tune-up limit is the maximum rated power among all production units.

∴ Scaling Factor :1.41

Reported SAR(W/㎏)= Measured SAR(W/㎏)* Scaling Factor
The above DUT's power and tune-up tolerance were declared by manufacturer.

2. Per KDB 447498 D01v05r02, for each exposure position, if the highest output channel reported SAR ≤ 0.8W/㎏, other channels SAR testing is not necessary.

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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	4.3	rectangular	√3	1	1	2.5	2.5
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.)	3.6	normal	1	0.7	0.5	2.5	1.8
Liquid Permittivity(target)	5.0	rectangular	√3	0.6	0.5	1.7	1.4
Liquid Permittivity(meas.)	0.7	normal	1	0.6	0.5	0.4	0.4
Combined Uncertainty		RSS				8.9	8.7
Combined Uncertainty (coverage factor=2)		Normal(k=2)				17.9	17.4

[Exposure Assessment Measurement Uncertainty]

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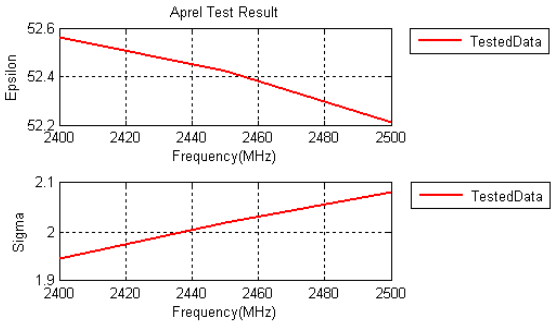
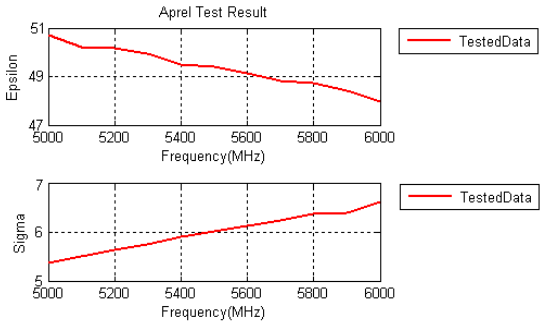
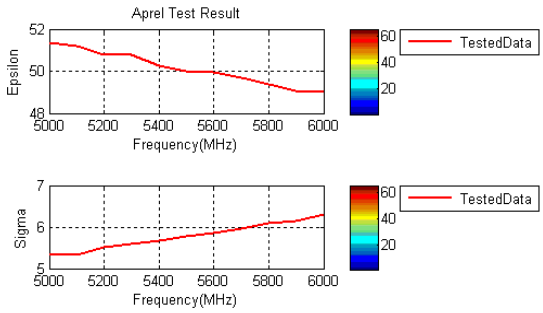
Appendix A : Plot of measured tissue.



2 450 ㎒ (2014.02.12)



5 200 ㎒, 5 400 ㎒ (2014.02.20)



5 600 ㎒, 5 800 ㎒ (2014.02.21)

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Appendix B : Plot of system verification test.

▣ **2 450 ㎒ (2014.02.12)**

SAR Test Report

```
Report Date      : 12-Feb-2014
By Operator      : Miyoung.Lee
Measurement Date  : 12-Feb-2014
Starting Time    : 12-Feb-2014  09:34:04 AM
End Time         : 12-Feb-2014  09:58:41 AM
Scanning Time    : 1477 secs

Product Data
Device Name      : 2450 MHz Dipole
Serial No.       : 220-00764
Type            : Dipole
Model           : ALS-D-2450-S-2
Frequency        : 2450.00 MHz
Max. Transmit Pwr : 0.01 W
Drift Time       : 10 min(s)
Length          : 52.5 mm
Width           : 3.6 mm
Depth           : 17 mm
Antenna Type     : Internal
Orientation      : Touch
Power Drift-Start : 5.739 W/kg
Power Drift-Finish: 5.903 W/kg
Power Drift (%)   : 2.858
Picture          :

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

Tissue Data
Type           : BODY
Serial No.      : 2450B
Frequency       : 2450.00 MHz
Last Calib. Date : 12-Feb-2014
Temperature     : 20.00 °C
Ambient Temp.    : 21.00 °C
Humidity        : 35.00 RH%
Epsilon         : 52.33 F/m
Sigma           : 2.02 S/m
Density         : 1000.00 kg/cu. m
```

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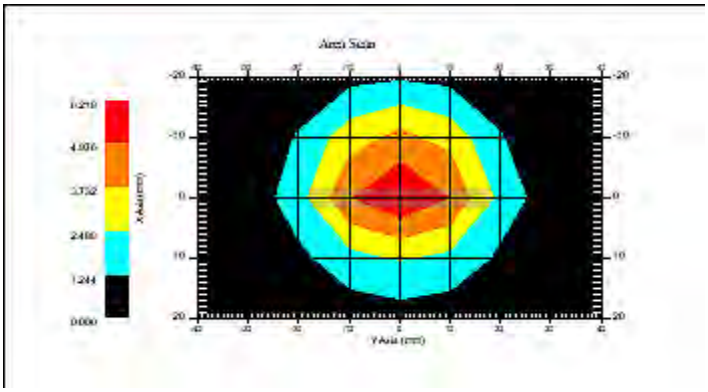
Probe Data
Name : E-Field
Model : E-020
Type : E-Field Triangle
Serial No. : 271_CW
Last Calib. Date : 02-Jul-2013
Frequency : 2450.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 4.3
Probe Sensitivity: 1.20 1.20 1.20 $\mu V/(V/m)^2$
Compression Point: 95.00 mV
Offset : 1.56 mm

Measurement Data
Crest Factor : 1
Scan Type : Complete
Tissue Temp. : 21.00 °C
Ambient Temp. : 22.00 °C
Set-up Date : 12-Feb-2014
Set-up Time : 9:32:38 AM
Area Scan : 5x9x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan : 7x7x7 : Measurement x=5mm, y=5mm, z=5mm

Other Data
DUT Position : Touch
Separation : 15



1 gram SAR value : 5.374 W/kg
10 gram SAR value : 2.426 W/kg
Area Scan Peak SAR : 5.904 W/kg
Zoom Scan Peak SAR : 10.280 W/kg

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▣ **5 200 ㎒ (2014.02.20)**

SAR Test Report

```
Report Date      : 20-Feb-2014
By Operator      : Miyoung.Lee
Measurement Date  : 20-Feb-2014
Starting Time    : 20-Feb-2014  09:02:30 AM
End Time         : 20-Feb-2014  09:34:39 AM
Scanning Time    : 1929 secs

Product Data
Device Name      : BB Dipole
Serial No.       : 235-00807
Type            : Dipole
Model           : ALS-D-BB-S-2
Frequency        : 5200.00 MHz
Max. Transmit Pwr : 0.1 W
Drift Time       : 10 min(s)
Length          : 22 mm
Width           : 3.6 mm
Depth           : 18.5 mm
Antenna Type     : Internal
Orientation      : Touch
Power Drift-Start : 6.413 W/kg
Power Drift-Finish: 6.520 W/kg
Power Drift (%)   : 1.664
Picture          :

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

Tissue Data
Type           : BODY
Serial No.      : 5200B
Frequency       : 5200.00 MHz
Last Calib. Date : 20-Feb-2014
Temperature     : 21.00 °C
Ambient Temp.    : 21.00 °C
Humidity        : 35.00 RH%
Epsilon         : 50.19 F/m
Sigma           : 5.34 S/m
Density         : 1000.00 kg/cu. m
```

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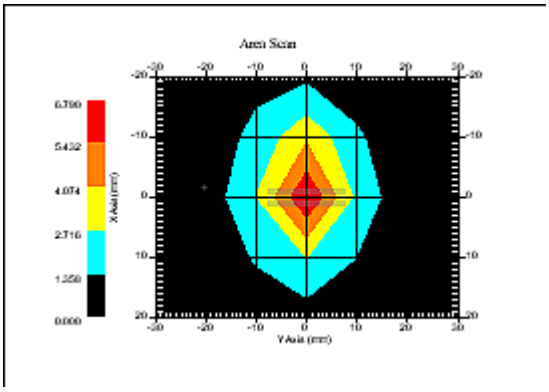
Probe Data
Name : E-Field
Model : E-020
Type : E-Field Triangle
Serial No. : 271_CW
Last Calib. Date : 02-Jul-2013
Frequency : 5200.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 2.8
Probe Sensitivity: 1.20 1.20 1.20 $\mu V/(V/m)^2$
Compression Point: 95.00 mV
Offset : 1.56 mm

Measurement Data
Crest Factor : 1
Scan Type : Complete
Tissue Temp. : 21.00 °C
Ambient Temp. : 21.00 °C
Set-up Date : 20-Feb-2014
Set-up Time : 8:20:00 AM
Area Scan : 5x7x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan : 7x7x12 : Measurement x=4mm, y=4mm, z=2mm

Other Data
DUT Position : Touch
Separation : 10



1 gram SAR value : 6.286 W/kg
10 gram SAR value : 2.119 W/kg
Area Scan Peak SAR : 6.790 W/kg
Zoom Scan Peak SAR : 16.713 W/kg

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▣ **5 400 ㎒ (2014.02.20)**

SAR Test Report

```
Report Date      : 20-Feb-2014
By Operator      : Miyoung.Lee
Measurement Date  : 20-Feb-2014
Starting Time    : 20-Feb-2014  09:46:13 AM
End Time         : 20-Feb-2014  10:18:06 AM
Scanning Time    : 1913 secs

Product Data
Device Name      : BB Dipole
Serial No.       : 235-00807
Type            : Dipole
Model           : ALS-D-BB-S-2
Frequency        : 5400.00 MHz
Max. Transmit Pwr : 0.1 W
Drift Time       : 10 min(s)
Length          : 22 mm
Width           : 3.6 mm
Depth           : 18.5 mm
Antenna Type     : Internal
Orientation      : Touch
Power Drift-Start : 6.149 W/kg
Power Drift-Finish: 6.172 W/kg
Power Drift (%)   : 0.373
Picture          :

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

Tissue Data
Type           : BODY
Serial No.      : 5400B
Frequency       : 5400.00 MHz
Last Calib. Date : 20-Feb-2014
Temperature     : 21.00 °C
Ambient Temp.    : 21.00 °C
Humidity        : 35.00 RH%
Epsilon         : 49.49 F/m
Sigma           : 5.56 S/m
Density         : 1000.00 kg/cu. m
```

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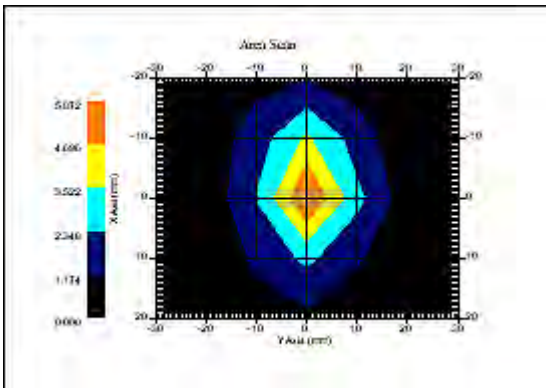
```
Probe Data
Name           : E-Field
Model          : E-020
Type           : E-Field Triangle
Serial No.      : 271_CW
Last Calib. Date : 02-Jul-2013
Frequency       : 5400.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 2.7
Probe Sensitivity: 1.20  1.20  1.20   μV/(V/m)²
Compression Point: 95.00 mV
Offset          : 1.56 mm

Measurement Data
Crest Factor    : 1
Scan Type       : Complete
Tissue Temp.    : 21.00 °C
Ambient Temp.   : 21.00 °C
Set-up Date     : 20-Feb-2014
Set-up Time     : 9:43:42 AM
Area Scan       : 5x7x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan       : 7x7x12 : Measurement x=4mm, y=4mm, z=2mm

Other Data
DUT Position    : Touch
Separation      : 10
```



```
1 gram SAR value   : 6.407 W/kg
10 gram SAR value  : 2.101 W/kg
Area Scan Peak SAR : 5.872 W/kg
Zoom Scan Peak SAR : 16.713 W/kg
```

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▣ **5 600 ㎒ (2014.02.21)**

SAR Test Report

```
Report Date      : 21-Feb-2014
By Operator      : Miyoung.Lee
Measurement Date  : 21-Feb-2014
Starting Time     : 21-Feb-2014  10:28:31 AM
End Time         : 21-Feb-2014  10:59:02 AM
Scanning Time     : 1831 secs

Product Data
Device Name       : BB Dipole
Serial No.        : 235-00807
Type             : Dipole
Model            : ALS-D-BB-S-2
Frequency         : 5600.00 MHz
Max. Transmit Pwr : 0.1 W
Drift Time        : 10 min(s)
Length           : 22 mm
Width            : 3.6 mm
Depth            : 18.5 mm
Antenna Type      : Internal
Orientation       : Touch
Power Drift-Start : 6.768 W/kg
Power Drift-Finish: 6.776 W/kg
Power Drift (%)   : 2.545
Picture          :

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

Tissue Data
Type            : BODY
Serial No.       : 5600B
Frequency        : 5600.00 MHz
Last Calib. Date : 21-Feb-2014
Temperature      : 21.00 °C
Ambient Temp.    : 21.00 °C
Humidity         : 35.00 RH%
Epsilon          : 49.97 F/m
Sigma            : 5.86 S/m
Density          : 1000.00 kg/cu. m
```

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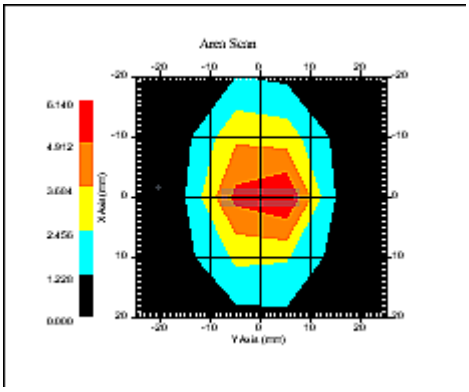
```
Probe Data
Name           : E-Field
Model          : E-020
Type           : E-Field Triangle
Serial No.      : 271_CW
Last Calib. Date : 02-Jul-2013
Frequency       : 5600.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 2.6
Probe Sensitivity: 1.20  1.20  1.20   μV/(V/m)²
Compression Point: 95.00 mV
Offset          : 1.56 mm

Measurement Data
Crest Factor    : 1
Scan Type       : Complete
Tissue Temp.    : 21.00 °C
Ambient Temp.   : 21.00 °C
Set-up Date     : 21-Feb-2014
Set-up Time     : 9:29:05 AM
Area Scan       : 5x6x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan       : 7x7x12 : Measurement x=4mm, y=4mm, z=2mm

Other Data
DUT Position    : Touch
Separation      : 10
```




```
1 gram SAR value   : 6.701 W/kg
10 gram SAR value  : 2.106 W/kg
Area Scan Peak SAR : 6.140 W/kg
Zoom Scan Peak SAR : 19.715 W/kg
```

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▣ **5 800 ㎒ (2014.02.21)**

SAR Test Report

```
Report Date      : 21-Feb-2014
By Operator      : Miyoung.Lee
Measurement Date  : 21-Feb-2014
Starting Time    : 21-Feb-2014  08:35:34 PM
End Time         : 21-Feb-2014  09:11:26 PM
Scanning Time    : 1912 secs

Product Data
Device Name      : BB Dipole
Serial No.       : 235-00807
Type            : Dipole
Model           : ALS-D-BB-S-2
Frequency        : 5800.00 MHz
Max. Transmit Pwr : 0.1 W
Drift Time       : 10 min(s)
Length          : 22 mm
Width           : 3.6 mm
Depth           : 18.5 mm
Antenna Type     : Internal
Orientation      : Touch
Power Drift-Start : 6.195 W/kg
Power Drift-Finish: 6.146 W/kg
Power Drift (%)   : -0.790
Picture          :

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

Tissue Data
Type            : BODY
Serial No.       : 5800B
Frequency        : 5800.00 MHz
Last Calib. Date : 21-Feb-2014
Temperature      : 21.00 °C
Ambient Temp.    : 21.00 °C
Humidity         : 35.00 RH%
Epsilon          : 49.60 F/m
Sigma           : 6.09 S/m
Density          : 1000.00 kg/cu. m
```

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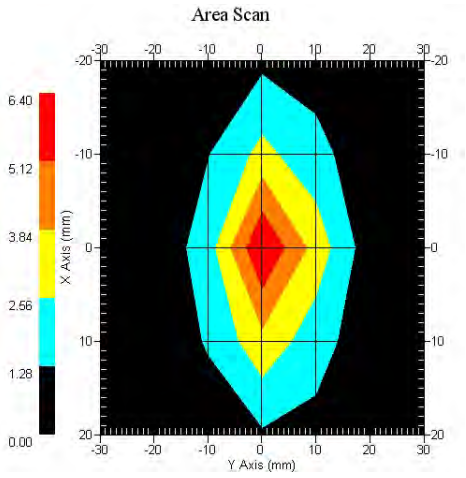
Probe Data
Name : E-Field
Model : E-020
Type : E-Field Triangle
Serial No. : 271_CW
Last Calib. Date : 02-Jul-2013
Frequency : 5800.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 2.8
Probe Sensitivity: 1.20 1.20 1.20 $\mu V/(V/m)^2$
Compression Point: 95.00 mV
Offset : 1.56 mm

Measurement Data
Crest Factor : 1
Scan Type : Complete
Tissue Temp. : 21.00 °C
Ambient Temp. : 21.00 °C
Set-up Date : 21-Feb-2014
Set-up Time : 3:04:08 PM
Area Scan : 5x7x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan : 7x7x12 : Measurement x=4mm, y=4mm, z=2mm

Other Data
DUT Position : Touch
Separation : 10



SAR value : 6.533 W/kg
10 gram SAR value : 2.212 W/kg
Area Scan Peak SAR : 6.398 W/kg
Zoom Scan Peak SAR : 17.814 W/kg

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Appendix C : Plot of SAR test.

Highest SAR Plot

SAR Test Report

```
Report Date      : 12-Feb-2014
By Operator      : Miyoung.Lee
Measurement Date  : 12-Feb-2014
Starting Time    : 12-Feb-2014  04:50:37 PM
End Time         : 12-Feb-2014  05:22:00 PM
Scanning Time    : 1883 secs

Product Data
Device Name      : Bluebird Inc.
Serial No.       : Proto Type
Type            : PDA
Model           : BM-180
Frequency        : 2437.00 MHz
Max. Transmit Pwr : 0.025 W
Drift Time       : 10 min(s)
Length          : 22 mm
Width           : 150 mm
Depth           : 22 mm
Antenna Type     : Internal
Orientation      : Touch
Power Drift-Start : 0.181 W/kg
Power Drift-Finish: 0.185 W/kg
Power Drift (%)   : 4.260
Picture          : C:\Alsas\bitmap\Device-23.bmp

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

Tissue Data
Type            : BODY
Serial No.       : 2450B
Frequency        : 2450.00 MHz
Last Calib. Date : 12-Feb-2014
Temperature      : 20.00 °C
Ambient Temp.    : 21.00 °C
Humidity         : 35.00 RH%
Epsilon          : 52.33 F/m
Sigma           : 2.02 S/m
Density          : 1000.00 kg/cu. m
```

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```
Probe Data
Name           : E-Field
Model          : E-020
Type           : E-Field Triangle
Serial No.      : 271_CW
Last Calib. Date : 02-Jul-2013
Frequency       : 2450.00 MHz
Duty Cycle Factor: 1
Conversion Factor: 4.3
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     : 12-Feb-2014
Set-up Time     : 10:48:56 AM
Area Scan       : 5x17x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan       : 7x7x7 : Measurement x=5mm, y=5mm, z=5mm

Other Data
DUT Position    : Touch
Separation      : 5
Channel         : Mid
```

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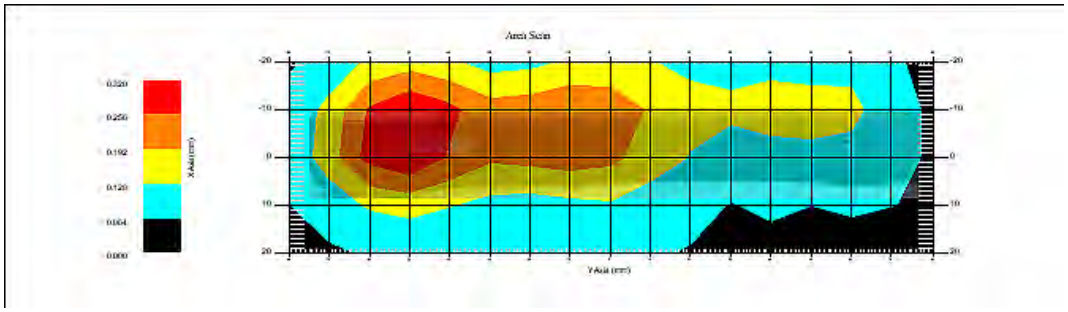

1 gram SAR value : 0.336 W/kg
10 gram SAR value : 0.179 W/kg
Area Scan Peak SAR : 0.319 W/kg
Zoom Scan Peak SAR : 0.620 W/kg

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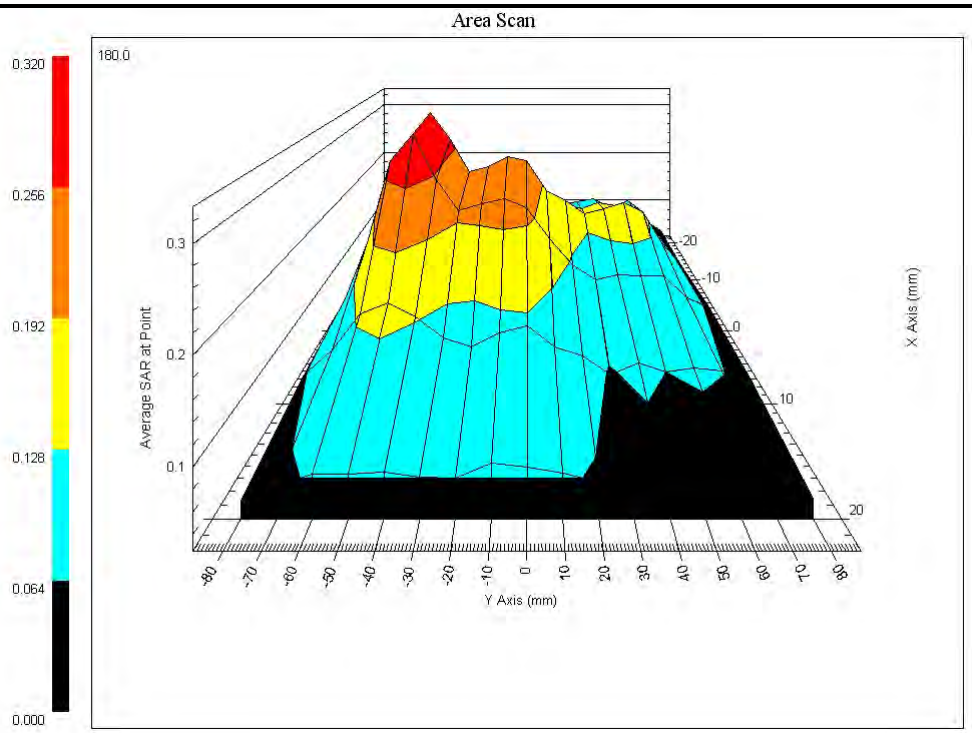
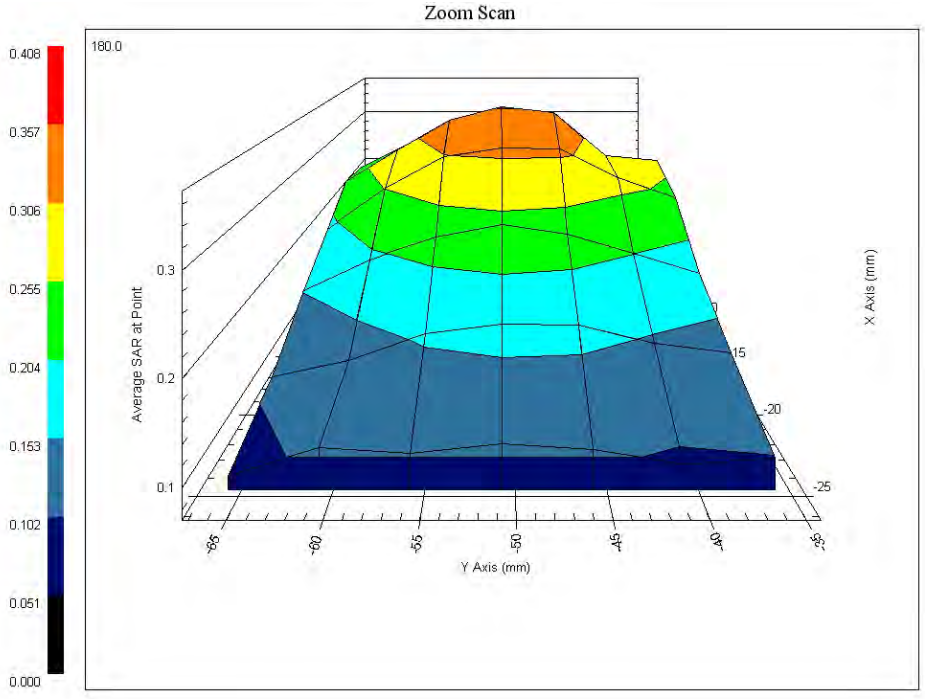


AREA SCAN Graph



ZOOM SCAN Graph

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Appendix D: DUT setup photos

[Front]

[Rear]

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[Top_Edge 1]

[Left_ Edge 4]

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Appendix E: System Certificate & calibration

E-1: Probe Calibration

NCL CALIBRATION LABORATORIES

Calibration File No.: 1218

Customer: Kostec
28(175-20, Annyeong-dong)406-gil sejaro, Hwaseong-si Gyeong-do, 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

Manufacturer: APREL Laboratories
Model No.: ALS-E020
Serial No.: 500-00271
Frequency.: Various

Calibration Procedure: D01-032-E020-V2, D22-012-Tissue, D28-002-Dipole
Project No: KOST-PC-5719

Calibrated: 2th July 2013
Released on: 2th July 2013

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

Released By: _____

Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES

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Kanata, Ontario
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NCL Calibration Laboratories

Division of APREL Inc.

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 of the probe through meteorgical practices.

Calibration Method

Probes are calibrated using the following methods.

<1000MHz
TEM Cell for sensitivity in air
Standard phantom using temperature transfer method for sensitivity in tissue

>1000MHz
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 (2003) including Amendment 1
  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 Ed. 1.0 (2010-03)
  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 Draft 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 re-calibration.

Ambient Temperature of the Laboratory: 22 °C +/- 1.5°C
Temperature of the Tissue: 21 °C +/- 1.5°C
Relative Humidity: < 54%

Primary Measurement Standards

Instrument	Serial Number	Cal due date
Attenuator HP 8495A (70dB)	2748A07325	March, 2014
Network Analyzer Anritsu 37347C	002106	Feb.. 2015
Secondary Measurement Standards		
Signal Generator HP 83640B	3844A00689	February 12, 2015
Power meter Agilent E4416A	MY45101929	October, 2013
Power Sensor Agilent E9323A	MY4421557	November, 2013

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

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Probe Summary

Probe Type:	E-Field Probe E020
Sensor Offset:	1.56
Sensor Length:	2.5
Tip Enclosure:	Composite*
Tip Diameter:	< 2.9 mm
Tip Length:	55 mm
Total Length:	289 mm

*Resistive to recommended tissue recipes per IEEE-1528

Sensitivity in Air

Channel X:	1.2 $\mu V/(V/m)^2$
Channel Y:	1.2 $\mu V/(V/m)^2$
Channel Z:	1.2 $\mu V/(V/m)^2$
Diode Compression Point:	95 mV

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Calibration for Tissue (Head H, Body B)

Frequency	Tissue Type	Measured Epsilon	Measured Sigma	Calibration Uncertainty	Tolerance Uncertainty for 5%*	Conversion Factor
450 H	**Head**	**45.58**	**0.88**	**3.5**	**2.4**	**6.6**
450 B	Body	X	X	X	X	X
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**	**41.85**	**0.88**	**3.5**	**3.4**	**7.0**
835 B	**Body**	**56.65**	**1.02**	**3.5**	**2.5**	**6.5**
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**	**40.55**	**1.38**	**3.5**	**2.4**	**5.1**
1800 B	Body	X	X	X	X	X
1900 H	**Head**	**38.55**	**1.33**	**3.5**	**2.5**	**5.6**
1900 B	**Body**	**51.69**	**1.59**	**3.5**	**2.5**	**5.4**
2000 H	**Head**	**39.15**	**1.35**	**3.5**	**2.5**	**5.6**
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**	**38.68**	**1.87**	**3.5**	**2.5**	**4.5**
2450 B	**Body**	**50.87**	**2.99**	**3.5**	**2.5**	**4.3**
2600 H	Head	X	X	X	X	X
2600 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**	**36.30**	**4.55**	**3.5**	**2.5**	**3.1**
5200 B	**Body**	**47.41**	**5.08**	**3.5**	**2.5**	**2.8**
5400 H	**Head**	**35.71**	**4.75**	**3.5**	**2.5**	**2.8**
5400 B	**Body**	**46.72**	**5.27**	**3.5**	**2.5**	**2.7**
5600 H	**Head**	**35.14**	**4.94**	**3.5**	**2.5**	**2.7**
5600 B	**Body**	**46.50**	**5.67**	**3.5**	**2.5**	**2.6**
5800 H	**Head**	**34.71**	**5.19**	**3.5**	**2.5**	**3.1**
5800 B	**Body**	**45.61**	**5.95**	**3.5**	**2.5**	**2.8**

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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.

Boundary Effect:

For a distance of 0.58mm the worst case evaluated uncertainty (increase in the probe sensitivity) is less than 2.1%.

NOTES:

*The maximum deviation from the centre frequency when comparing the lower to upper range is listed.

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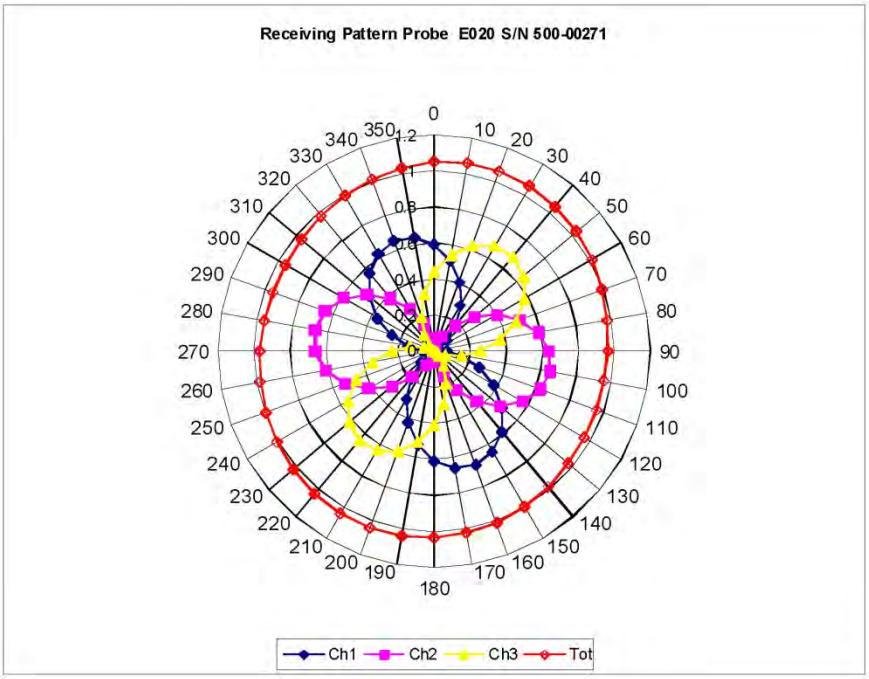
Receiving Pattern Air



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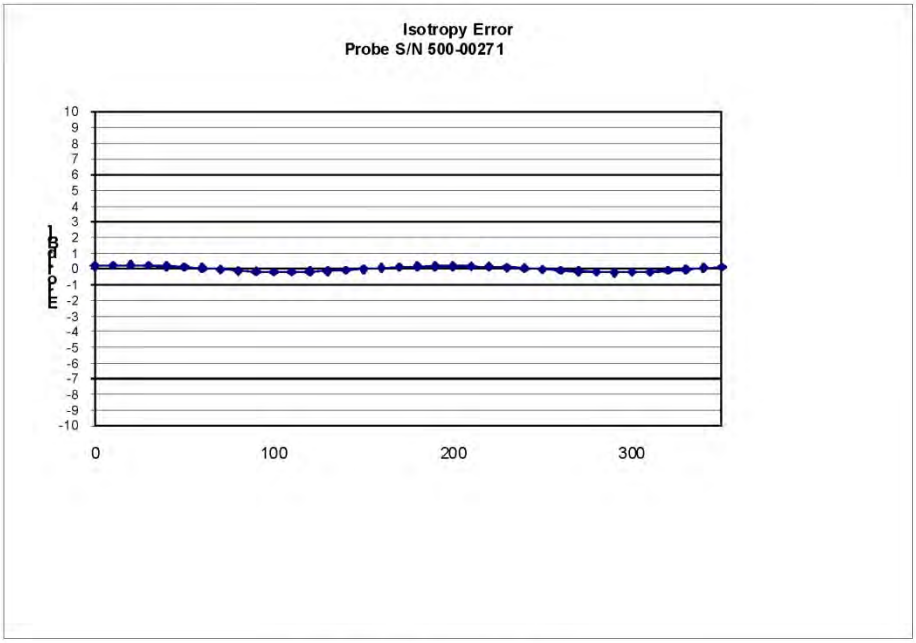
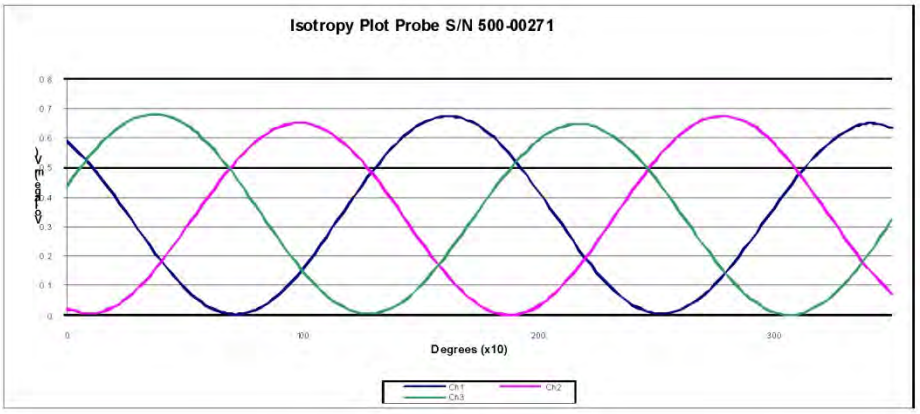
Isotropy Error (Air)





Isotropicity Tissue: 0.189 dB

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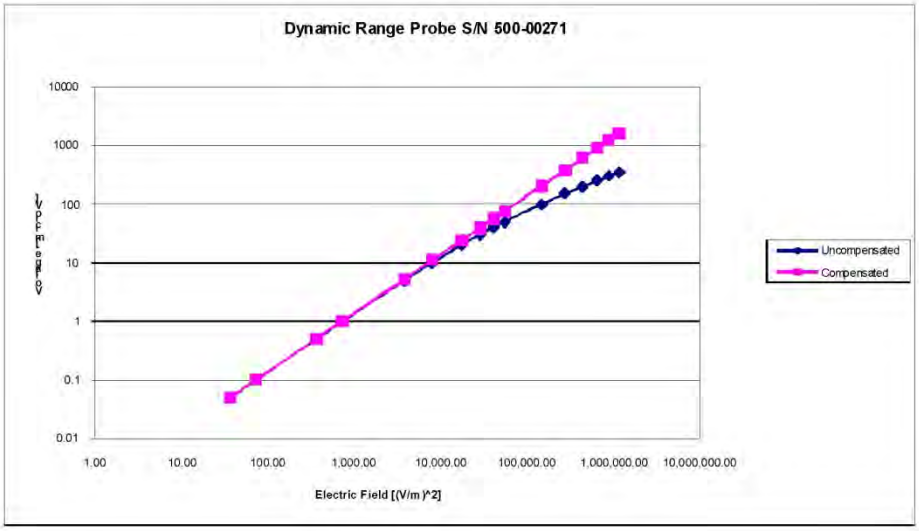
Dynamic Range



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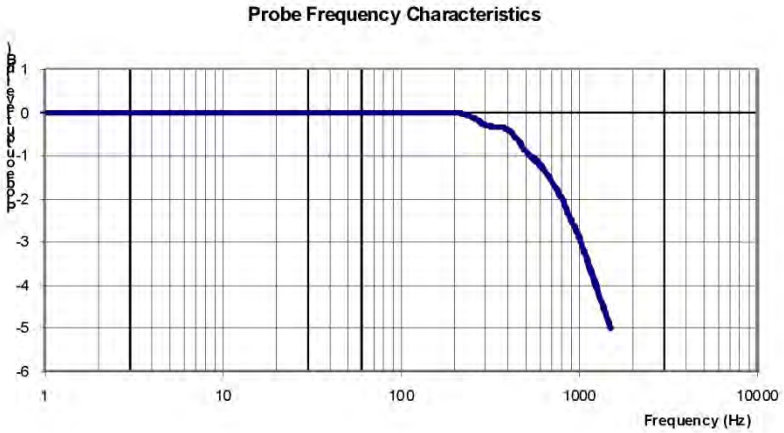
Video Bandwidth



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

Test Equipment

The te st eq uipment used du ring Probe Calibration, man ufacturer, mod el number and, cu rrent calibration status are li sted a nd l ocated on the main A PREL server R:\NCL\Calibration Equipment\Instrument List May 2012.

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ANNEX

PROBE ALS-E020 S/N 500-00272 CALIBRATION

Conditions

Ambient Temperature of the Laboratory: 22 °C +/- 1.5°C
Temperature of the Tissue: 21 °C +/- 1.5°C
Relative Humidity: < 54%

Sensitivity in Head Tissue

Frequency: 600 MHz

Epsilon: 43.8 **Sigma:** 0.83 S/m

The relative permittivity and conductivity values for frequency 600 MHz are not specified in IEEE 1528 and IEC 62209 standards. The target values were linearly interpolated utilizing the data from Table 2 IEEE 1528 (2003).

Dipole Mechanical Dimensions*

Length: 312 mm
Height: 166.56 mm

*450 MHz Dipole and Uni-Fhantom were used for these calibration procedures. For the system validation with APREL Flat Phantom the dipole should be aligned against the sort side of the phantom.

ConvF

Channel 1: 2.8

Channel 2: 2.8

Channel 3: 2.8

Conversion factors were determined in respect to the numerical simulation values (see Dipole ALS-D-450-S-2 Serial Number 175-00504 600 MHz Non-Standard Addendum).

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E-2: Dipole antenna Calibration

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1483
Project Number: KOST-DC-5722

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
2450MHz Head & Body

Manufacturer: APREL Laboratories
Part number: ALS-D-2450-S-2
Frequency: 2450MHz
Serial No: 220-00764

Customer: Kostec
28(175-20, Annyeong-dong)406-gil sejaro, Hwaseong-si Gyeong-do, Korea

Calibrated: 27th February 2013
Released on: 27th February 2013

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

Released By: _____
Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES
303 Terry Fox Drive, Suite 102
Kanata, Ontario
CANADA K2K 3J1

Division of APREL
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NCL Calibration Laboratories
Division of APREL Inc.

Conditions

Dipole 220-00764 was an original calibration. New taken from stock

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

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

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

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NCL Calibration Laboratories
Division of APREL Inc.

Calibration Results Summary

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

Mechanical Dimensions

Length: 52.50 mm
Height: 30.59 mm

Electrical Calibration

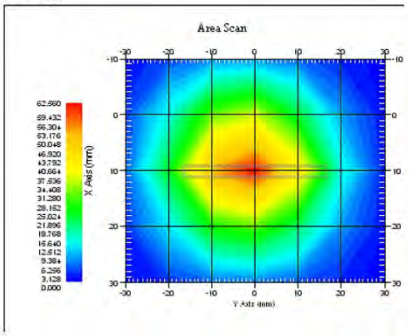
Tissue Type	Return Loss:	Impedance:	SWR:
Head	-41.522 dB	50.117 Ω	1.022U
Body	-31.148 dB	53.332 Ω	1.058 U

System Validation Results

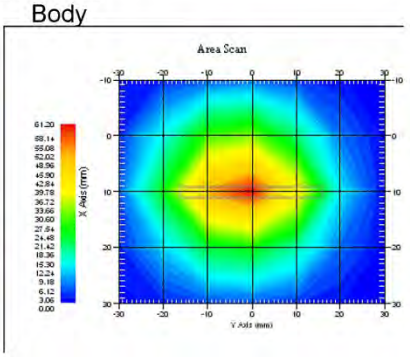
Tissue	Frequency	1 Gram	10 Gram	Peak
Head	2450 MHz	52.926	24.39	106.93
Body	2450 MHz	49.785	22.475	102.89

2450MHz

Head



Body



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NCL Calibration Laboratories
Division of APREL Inc.

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 220-00764. 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-030 130 MHz to 26 GHz E-Field Probe Serial Number 215.

References

- IEEE Standard 1528 (2003) including Amendment 1
  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 Ed. 1.0 (2010-03)
  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 Draft Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

Conditions

Dipole 220-00764 was an original calibration. New taken from stock.

Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 20 °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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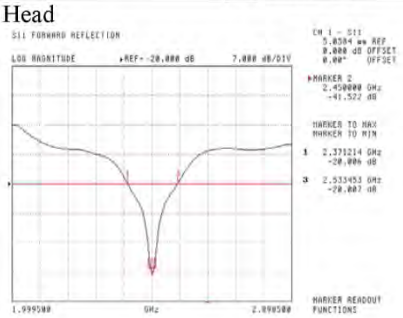
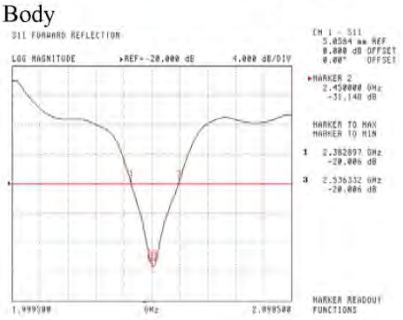
Electrical Calibration

Tissue Type	Return Loss:	Impedance:	SWR:
Head	-41.522 dB	50.117 Ω	1.022U
Body	-31.148 dB	53.332 Ω	1.058 U

Head



Body



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NCL Calibration Laboratories

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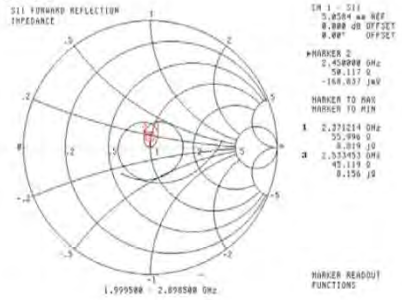
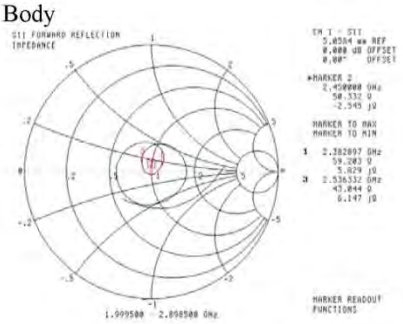
Head



Body



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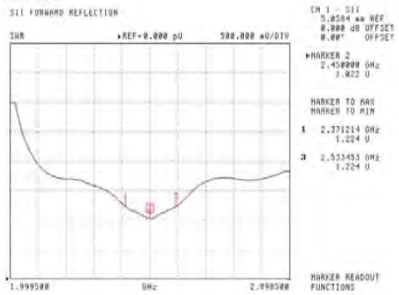
Head



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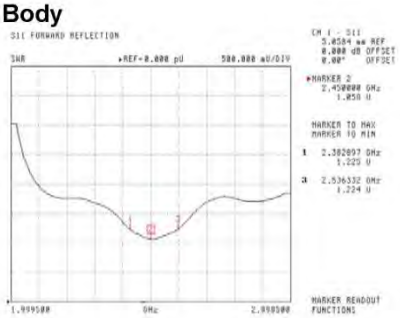

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Test Equipment

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2012.

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NCL CALIBRATION LABORATORIES

Calibration File No: DC-1484
Project Number: KOST-DC-5723

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
Broadband Head & Body

Manufacturer: APREL Laboratories
Part number: ALS-D-BB-S-2
Frequency: Broadband
Serial No: 235-00807

Customer: Kostec
28(175-20, Annyeong-dong)406-gil sejaro, Hwaseong-si Gyeong-do, Korea

Calibrated: 27th February 2013
Released on: 27th February 2013

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

Released By: _____

Art Brennan, Quality Manager

NCL CALIBRATION LABORATORIES

303 Terry Fox Drive, Suite 102
Kanata, Ontario
CANADA K2K 3J1

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

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Conditions

Dipole 235-00807 was an original calibration. New taken from stock

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

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

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Calibration Results Summary

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

Mechanical Dimensions

Length: 22.0 mm
Height: 18.5 mm

Electrical Calibration

	5200 MHz		5400 MHz		5600 MHz		5800 MHz	
	Head	Body	Head	Body	Head	Body	Head	Body
SWR U	1.2	1.198	1.117	1.109	1.148	1.151	1.183	1.202
Return Loss dB	-20.87	-20.921	-25.153	-25.696	-23.219	-23.050	-21.539	-20.741
Impedance Ω	54.638	54.968	55.750	55.391	53.293	53.248	58.519	58.957

System Validation Results

Tissue	Frequency	1 Gram	10 Gram	Peak
Head	5200 MHz	61.41	20.98	176.14
Body	5200 MHz	65.21	22.13	187.15
Head	5400 MHz	62.96	21.84	177.14
Body	5400 MHz	62.1	21.14	176.14
Head	5600 MHz	63.93	21.66	191.15
Body	5600 MHz	66.84	22.36	198.16
Head	5800 MHz	58.71	19.98	174.14
Body	5800 MHz	60.41	20.68	180.14

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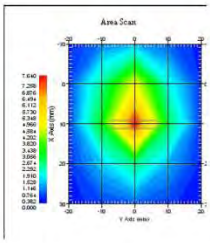
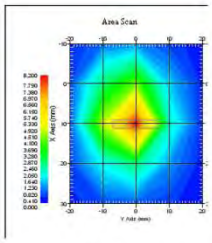
Broad Band

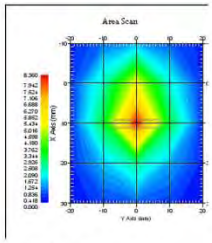
5200 MHz Head



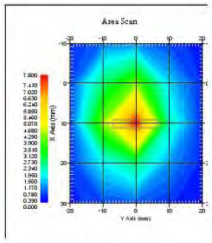
5200 MHz Body



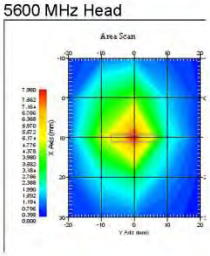
5400 MHz Head



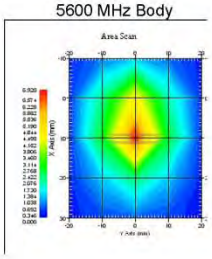
5400 MHz Body



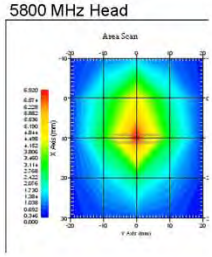
5600 MHz Head



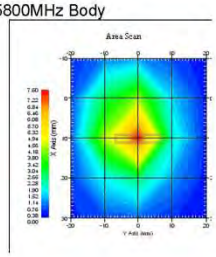
5600 MHz Body



5800 MHz Head



5800MHz Body



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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 235-00807. 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-030 130 MHz to 26 GHz E-Field Probe Serial Number 215.

References

- IEEE Standard 1528 (2003) including Amendment 1
  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 Ed. 1.0 (2010-03)
  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 Draft Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

Conditions

Dipole 235-00807 was an original calibration. New taken from stock.

Ambient Temperature of the Laboratory:	22 °C +/- 0.5°C
Temperature of the Tissue:	20 °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

	5200 MHz		5400 MHz		5600 MHz		5800 MHz	
	Head	Body	Head	Body	Head	Body	Head	Body
SWR U	1.2	1.198	1.117	1.109	1.148	1.151	1.183	1.202
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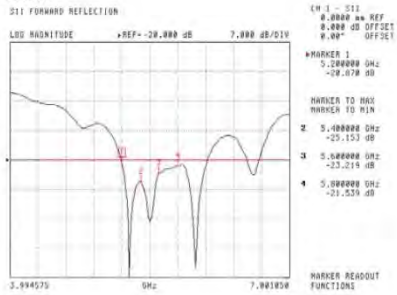
Impedance Ω	54.638	54.968	55.750	55.391	53.293	53.248	58.519	58.957

Head



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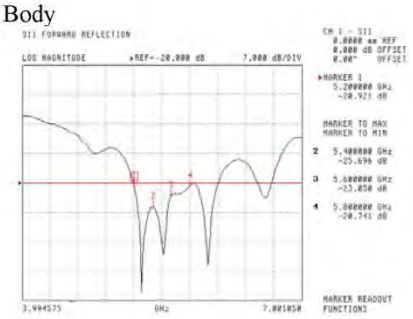

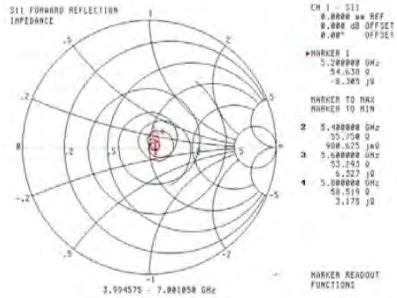

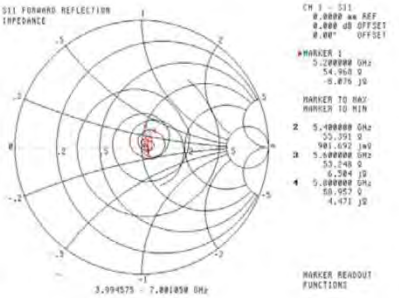

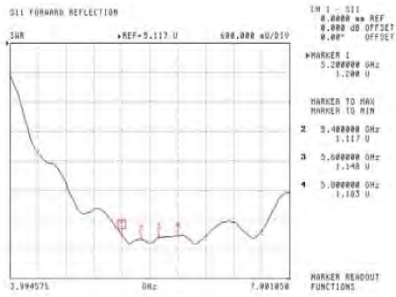

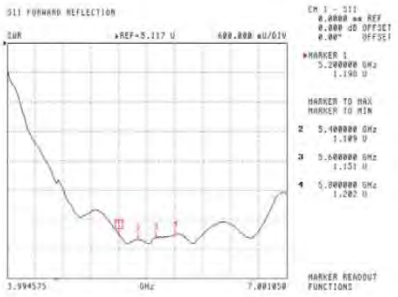

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