RF Exposure report

The following samples were submitted and identified on behalf of the client as:

Product Name	nRF9160 IOT Module
Brand Name	nRF91
Model No.	nRF9160
Applicant	NORDIC SEMICONDUCTOR ASA
	Otto Nielsens Vei 12, 7052 Trondheim, Norway
Standards	IEEE/ANSI C95.1-1992, IEEE 1528-2013
FCC ID	2ANPO00NRF9160
Date of EUT Receipt	Jul. 21, 2022
Date of Test(s)	Aug. 09, 2022 ~ Aug. 12, 2022
Date of Issue	Sep. 22, 2022

In the configuration tested, the EUT complied with the standards specified above.

Remarks:

This report details the results of the testing carried out on one sample, the results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

This report may only be reproduced and distributed in full. If the product in this report is used in any configuration other than that detailed in the report, the manufacturer must ensure the new system complies with all relevant standards. Any mention of SGS Taiwan Ltd. Central RF Lab or testing done by SGS Taiwan Ltd. Central RF Lab in connection with distribution or use of the product described in this report must be approved by SGS Taiwan Ltd. Central RF Lab in writing.

Signed on behalf of SGS

Clerk / Ruby Ou	PM / Kiki Lin	Approved By / John Yeh
Ruby Ou	Kiki Lin	John Yeh

Date: Sep. 22, 2022

Revision History

Report Number	Revision	Description	Issue Date	Revised By	Remark
TESA2207000226ES	00	Initial creation of document	Sep. 22, 2022	Ruby Ou	

Note:

1. The mark " * " is the revised version of the report due to comments submitted by the certification.

Contents

1 GENERAL INFORMATION

1.1 Test Methodology

The SAR testing method and procedure for this device is in accordance with the following standards:
IEEE/ANSI C95.1-1992
IEEE 1528-2013
KDB447498D01v06
KDB865664D01v01r04
KDB865664D02v01r02
KDB941225D05v02r05

1.2 Description of EUT

Host Information:

Product Name	VanMoof Generation 5 eBike Controller	
Brand Name	VanMoof	
Model No.	VTE-001	
FCC ID	2ANPO00NRF9160	
Duty Cycle	LTE FDD	1
	Bluetooth	0.631
Supported radios (TX Frequency Range, MHz)	LTE FDD Band 26	814-849
	Bluetooth 5.2	2.4GHz (2400.0 – 2483.5 MHz)

1.3 Maximum value

CAT.M1

Max. SAR (1 g) (W/kg)				
Band	Measured	Reported	Channel	Position
LTE Band 26	0.45	0.50	26965	Bottom view

2 MEASUREMENT SYSTEM

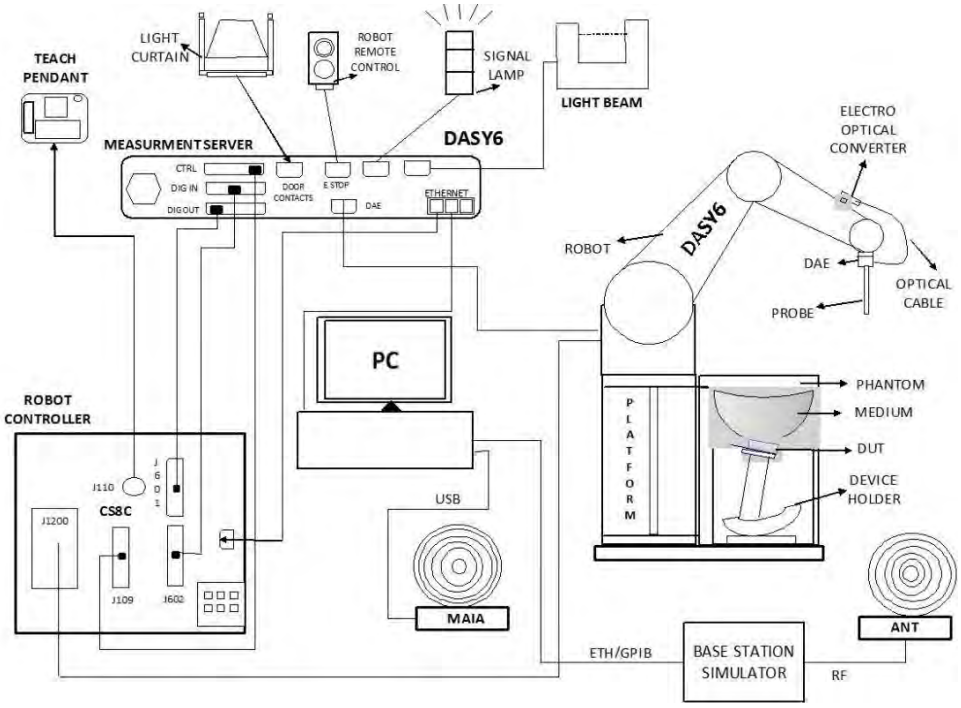
2.1 Test Facility

Laboratory	Test Site Address	Test Site Name	FCC Designation number	IC CAB identifier
SGS Taiwan Ltd. Central RF Lab. (TAF code 3702)	1F, No. 8, Alley 15, Lane 120, Sec. 1, NeiHu Road, Neihu District, Taipei City, 11493, Taiwan.	SAR 2	TW0029	**TW3702**
		SAR 6		
	No. 2, Keji 1st Rd., Guishan Township, Taoyuan County, 33383, Taiwan	SAR 1	TW0028	
		SAR 4		
	No.134, Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan	**SAR 3**	**TW0027**	
		SAR 7		
Note: Test site name is remarked on the equipment list in each section of this report as an indication where measurements occurred in specific test site and address.				

2.2 SAR System

Block Diagram (DASY6)

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



- A standard high precision 6-axis robot with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running Windows 10 and the DASY6 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

EX3DV4 E-Field Probe

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
Calibration	Basic Broad Band Calibration in air Conversion Factors (CF) for HSL 835/2450 MHz Additional CF for other liquids and frequencies upon request	
Frequency	10 MHz to > 6 GHz	
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)	
Dynamic Range	10 µW/g to > 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 µW/g)	
Dimensions	Tip diameter: 2.5 mm	
Application	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%.	

PHANTOM (ELI)

Model	ELI	
Construction	The ELI phantom is used for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.	
Shell Thickness	2 ± 0.2 mm	
Filling Volume	Approx. 30 liters	
Dimensions	Major axis: 600 mm Minor axis: 400 mm	

DEVICE HOLDER (ELI)

Construction	The device holder (Supporter) for Notebook is made by POM (polyoxymethylene resin) , which is non-metal and non-conductive. The height can be adjusted to fit varies kind of notebooks.	 Device Holder

3 SAR SYSTEM VERIFICATION

3.1 Tissue Simulating Liquid

For the measurement of the field distribution inside the SAM phantom with DASY, the phantom must be filled with homogeneous tissue simulating liquid. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15cm. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15cm.

3.2 Tissue Simulant Liquid measurement

The dielectric properties for this Head-simulant fluid were measured by using the SPEAG Dielectric Assessment Kit (DAKS-3.5)
All dielectric parameters of tissue simulates were measured within 24 hours of SAR measurements. The measured conductivity and permittivity are all within ± 5% of the target values.

3.3 Measurement results of Tissue Simulant Liquid

Measured Frequency (MHz)	Liquid Temp. (°C)	Target Dielectric Constant, εr	Target Conductivity, σ (S/m)	Measured Dielectric Constant, εr	Measured Conductivity, σ (S/m)	% dev εr	% dev σ	Limit	Measurement Date
814.1	22.7	41.609	0.898	42.631	0.928	2.46%	3.25%	± 5%	Aug. 09, 2022
821.5	22.7	41.564	0.898	42.602	0.931	2.50%	3.62%	± 5%	Aug. 09, 2022
831.5	22.7	41.516	0.900	42.566	0.935	2.53%	3.93%	± 5%	Aug. 09, 2022
835	22.7	41.500	0.900	42.129	0.942	1.52%	4.67%	± 5%	Aug. 09, 2022
841.5	22.7	41.500	0.907	42.529	0.939	2.48%	3.51%	± 5%	Aug. 09, 2022
848.9	22.7	41.500	0.915	42.504	0.941	2.42%	2.89%	± 5%	Aug. 09, 2022
2402	22.7	39.282	1.757	41.131	1.786	4.71%	1.62%	± 5%	Aug. 12, 2022
2450	22.7	39.200	1.800	41.048	1.797	4.71%	-0.17%	± 5%	Aug. 12, 2022

3.4 The composition of the tissue simulating liquid:

Simulating Liquids for 600 MHz -10 GHz, Manufactured by SPEAG:

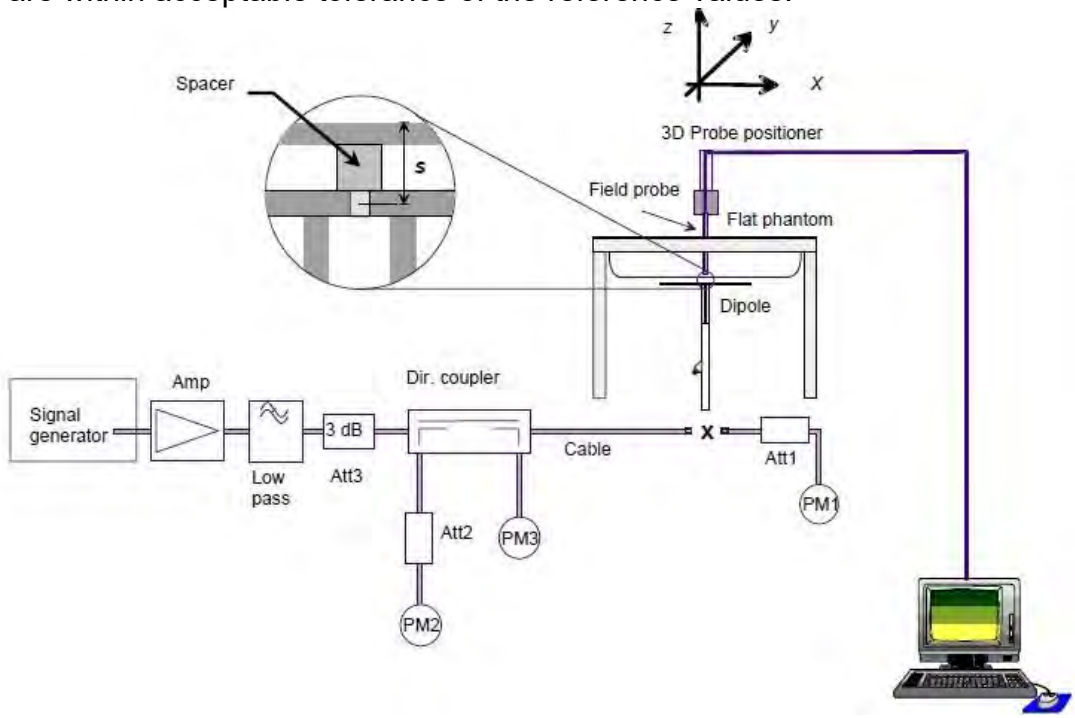
Broad-band head tissue simulating liquids	SPEAG Product	Frequency range (MHz)	Main Ingredients
	HBBL600-10000V6	600 - 10000	Water, Oil

3.5 System check

The microwave circuit arrangement for system check is sketched in below. The daily system accuracy verification occurs within the flat section of the SAM phantom and ELI phantom. A SAR measurement was performed to see if the measured SAR was within +/- 10% from the target SAR values.

The tests were conducted on the same days as the measurement of the DUT. The obtained results from the system accuracy verification are displayed with SAR values normalized to 1W forward power delivered to the dipole.

During the tests, the liquid depth from the center of the flat phantom to the liquid top surface was 15 cm above in all the cases. It is seen that the system is operating within its specification, as the results are within acceptable tolerance of the reference values.



The block diagram of system check

3.6 System check results

Validation Kit	S/N	Frequency (MHz)	1W Target 1g-SAR (W/kg)	pin=250mW Measured 1g-SAR (W/kg)	Normalized to 1W 1g-SAR (W/kg)	Deviation (%)	Limit	Measurement Date
D835V2	4d063	835	9.64	2.31	9.24	-4.15	± 10%	Aug.09,2022
D2450V2	727	2450	52.8	13.3	53.2	0.76	± 10%	Aug.12,2022

4 TEST CONFIGURATIONS

4.1 Test Environment

Ambient Temperature: 22±2° C
Tissue Simulating Liquid: 22±2° C

4.2 Test Note

- **General:** Measurements are performed respectively on the lowest, middle and highest channels of the operating band(s).
- **General:** The EUT is set to maximum power level during all tests, and at the beginning of each test the battery is fully charged.
- **General:** During the SAR testing, the DASY system checks power drift by comparing the e-field strength of one specific location measured at the beginning with that measured at the end of the SAR testing.
- **General:** According to KDB447498D01v06, testing of other required channels is not required when the reported 1-g SAR for the highest output channel is ≤ 0.8 W/kg, when the transmission band is ≤ 100 MHz.
- **General:** According to KDB865664D01v01r04, SAR measurement variability must be assessed for each frequency band. When the original highest measured SAR is ≥ 0.8 W/kg, repeated that measurement once. 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).
- **LTE:** LTE modes test according to **KDB 941225D05v02r05.**

a. Per Section 5.2.1, the largest channel bandwidth and measure SAR for QPSK with 1 RB allocation.

- Using the RB offset and required test channel combination with the highest maximum output power for RB offsets at the upper edge, middle and lower edge of each required test channel.
- When the reported SAR is ≤ 0.8 W/kg, testing of the remaining RB offset configurations and required test channels is not required for 1 RB allocation; otherwise, SAR is required for the remaining required test channels and only for the RB offset configuration with the highest output power for that channel.
- When the reported SAR of a required test channel is > 1.45 W/kg, SAR is required for all three RB offset configurations for that required test channel.

b. Per Section 5.2.2, the largest channel bandwidth and measure SAR for QPSK with 50% RB allocation

- The procedures required for 1 RB allocation in 5.2.1 are applied to measure the SAR for QPSK with 50% RB allocation.

c. Per Section 5.2.3, the largest channel bandwidth and measure SAR for QPSK with 100% RB allocation

- For QPSK with 100% RB allocation, SAR is not required when the highest

maximum output power for 100 % RB allocation is less than the highest maximum output power in 50% and 1 RB allocations and the highest reported SAR for 1 RB and 50% RB allocation in 5.2.1 and 5.2.2 are ≤ 0.8 W/kg.

- Otherwise, SAR is measured for the highest output power channel and if the reported SAR is > 1.45 W/kg, the remaining required test channels must also be tested.

d. Per Section 5.2.4, Higher order modulations

- For each modulation besides QPSK; e.g., 16-QAM, 64-QAM, apply the QPSK procedures in sections 5.2.1, 5.2.2 and 5.2.3 to determine the QAM configurations that may need SAR measurement. For each configuration identified as required for testing, SAR is required only when the highest maximum output power for the configuration in the higher order modulation is > ½ dB higher than the same configuration in QPSK or when the reported SAR for the QPSK configuration is > 1.45 W/kg.

e. Per Section 5.3, other channel bandwidth standalone SAR test requirements

- For the other channel bandwidths used by the device in a frequency band, apply all the procedures required for the largest channel bandwidth in section 5.2 to determine the channels and RB configurations that need SAR testing and only measure SAR when the highest maximum output power of a configuration requiring testing in the smaller channel bandwidth is > ½ dB higher than the equivalent channel configurations in the largest channel bandwidth configuration or the reported SAR of a configuration for the largest channel bandwidth is > 1.45 W/kg. The equivalent channel configuration for the RB allocation, RB offset and modulation etc. is determined for the smaller channel bandwidth according to the same number of RB allocated in the largest channel bandwidth.

4.3 Test position

Body SAR (15mm)

Body SAR is measured for top/bottom/edge1/edge2 with 15mm test distance.

4.4 Test limit

§ 2.1093(d)(1)
Applications for equipment authorization of portable RF sources subject to routine environmental evaluation must contain a statement confirming compliance with the limits specified in § 1.1310 as part of their application. Technical information showing the basis for this statement must be submitted to the Commission upon request. The SAR limits specified in § 1.1310(a) through (c) of this chapter shall be used for evaluation of portable devices transmitting in the frequency range from 100 kHz to 6 GHz. Portable devices that transmit at frequencies above 6 GHz shall be evaluated in terms of the MPE limits specified in Table 1 to § 1.1310(e)(1). A minimum separation distance applicable to the operating configurations and exposure conditions of the device shall be used for the evaluation. In general, maximum time-averaged power levels must be used for evaluation. All unlicensed personal communications service (PCS) devices and unlicensed NII devices shall be subject to the limits for general population/uncontrolled exposure.
Radiofrequency radiation exposure limits.
§ 1.1310(a)
Specific absorption rate (SAR) shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in § 1.1307(b) within the frequency range of 100 kHz to 6 GHz (inclusive).
§ 1.1310(b)
The SAR limits for occupational/controlled exposure are 0.4 W/kg, as averaged over the whole body, and a peak spatial-average SAR of 8 W/kg, averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the parts of the human body treated as extremities, such as hands, wrists, feet, ankles, and pinnae, where the peak spatial-average SAR limit for occupational/controlled exposure is 20 W/kg, averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube). Exposure may be averaged over a time period not to exceed 6 minutes to determine compliance with occupational/controlled SAR limits.
§ 1.1310(c)
The SAR limits for general population/uncontrolled exposure are 0.08 W/kg, as averaged over the whole body, and a peak spatial-average SAR of 1.6 W/kg, averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the parts of the human body treated as extremities, such as hands, wrists, feet, ankles, and pinnae, where the peak spatial-average SAR limit is 4 W/kg, averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube). Exposure may be averaged over a time period not to exceed 30 minutes to determine compliance with general population/uncontrolled SAR limits.

Note to paragraphs (a) through (c):
SAR is a measure of the rate of energy absorption due to exposure to RF electromagnetic energy. These SAR limits to be used for evaluation are based generally on criteria published by the American National Standards Institute (ANSI) for localized SAR in Section 4.2 of “IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz,” ANSI/IEEE Std C95.1-1992, copyright 1992 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017. These criteria for SAR evaluation are similar to those

recommended by the National Council on Radiation Protection and Measurements (NCRP) in "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86, Section 17.4.5, copyright 1986 by NCRP, Bethesda, Maryland 20814. Limits for whole body SAR and peak spatial-average SAR are based on recommendations made in both of these documents. The MPE limits in Table 1 are based generally on criteria published by the NCRP in "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86, Sections 17.4.1, 17.4.1.1, 17.4.2 and 17.4.3, copyright 1986 by NCRP, Bethesda, Maryland 20814. In the frequency range from 100 MHz to 1500 MHz, these MPE exposure limits for field strength and power density are also generally based on criteria recommended by the ANSI in Section 4.1 of "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE Std C95.1-1992, copyright 1992 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017.

Portable devices that transmit at frequencies above 6 GHz shall be evaluated in terms of the MPE limits specified in Table 1 to § 1.1310(e)(1).
According to ANSI/IEEE C95.1-1992, the criteria listed in the following Table shall be used to evaluate the environmental impact of human exposure to radio frequency (RF) radiation as specified in §1.1310.
Peak Spatially Averaged Power Density was evaluated over a circular area of 4cm2 per interim FCC Guidance for near-field power density evaluations per October 2018 TCB Workshop notes

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(i) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*(100)	≤6
3.0-30	1842/f	4.89/f	*($900/f^2$)	<6
30-300	61.4	0.163	1.0	<6
300-1,500			f/300	<6
1,500-100,000			5	<6
(ii) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	<30
1.34-30	824/f	2.19/f	*($180/f^2$)	<30
30-300	27.5	0.073	0.2	<30
300-1,500			f/1500	<30
1,500-100,000			1.0	<30

f = frequency in MHz. * = Plane-wave equivalent power density.
Table 1 to § 1.1310(e)(1) - Limits for Maximum Permissible Exposure (MPE)

5 MAXIMUM OUTPUT POWER

5.1 NB-IOT

LTE Band 26_NB-IoT							
Sub-carrier spacing (KHz)	Modulation	Ntones	Conducted power (dBm)			Target Power + Max. Tolerance (dBm)	MPR Allowed per 3GPP(dB)
Frequency (MHz)			814.1	831.5	848.9		
Channel			26691	26865	27039		
3.75kHz	BPSK	1@0	22.05	22.13	22.18	23.00	0.0
		1@47	22.01	22.10	21.98	23.00	0.0
15kHz	QPSK	1@0	22.18	22.27	22.35	23.00	0.0
		1@11	22.15	22.13	22.20	23.00	0.0
		3@3	22.20	22.21	22.13	23.00	0.0

5.2 CAT.M1

LTE Band 26_Cat.M1									
BW(MHz)	Modulation	RB Size	RB Offset	NB Index	Conducted power (dBm)			Target Power + Max. Tolerance (dBm)	MPR Allowed per 3GPP(dB)
Frequency (MHz)					821.5	831.5	841.5		
Channel					26765	26865	26965		
15	QPSK	1	0	0	22.37	22.41	22.58	23.00	0.0
		1	0	3	22.08	22.38	22.26	23.00	0.0
		1	5	8	22.23	22.29	22.21	23.00	0.0
		1	5	11	22.21	22.40	22.39	23.00	0.0
		3	0	0	22.13	22.31	22.32	23.00	0.0
		3	3	11	22.30	22.11	22.38	23.00	0.0
		6	0	0	21.56	21.79	21.88	22.50	0.5
		6	0	11	21.73	21.70	21.77	22.50	0.5
15	16-QAM	1	0	0	21.59	21.69	22.00	22.50	0.5
		1	0	3	21.79	21.89	21.82	22.50	0.5
		1	4	8	21.59	21.74	21.96	22.50	0.5
		1	4	11	21.65	21.68	21.73	22.50	0.5
		3	0	0	21.59	21.77	21.79	22.50	0.5
		3	2	11	21.81	21.60	21.86	22.50	0.5
		5	0	0	21.80	21.64	21.91	22.50	0.5
		5	0	11	21.65	21.67	21.80	22.50	0.5

LTE Band 26_Cat.M1									
BW(MHz)	Modulation	RB Size	RB Offset	NB Index	Conducted power (dBm)			Target Power + Max. Tolerance (dBm)	MPR Allowed per 3GPP(dB)
					819	831.5	844		
				Channel	26740	26865	26990		
10	QPSK	1	0	0	22.08	22.26	22.31	22.50	0.5
		1	0	3	22.10	22.31	22.36	22.50	0.5
		1	5	4	22.26	22.35	22.42	22.50	0.5
		1	5	7	22.24	22.34	22.21	22.50	0.5
		3	0	0	22.26	22.17	22.40	22.50	0.5
		3	3	7	22.30	22.38	22.21	22.50	0.5
		6	0	0	21.85	21.61	21.81	21.50	1.5
		6	0	7	21.61	21.63	21.71	21.50	1.5
10	16-QAM	1	0	0	21.57	21.66	21.89	22.50	0.5
		1	0	3	21.74	21.69	21.93	22.50	0.5
		1	4	4	21.79	21.66	21.95	22.50	0.5
		1	4	7	21.59	21.70	21.85	22.50	0.5
		3	0	0	21.71	21.65	22.00	22.50	0.5
		3	2	7	21.84	21.86	21.71	22.50	0.5
		5	0	0	21.66	21.69	21.91	21.50	1.5
		5	0	7	21.77	21.84	21.94	21.50	1.5

LTE Band 26_Cat.M1									
BW(MHz)	Modulation	RB Size	RB Offset	NB Index	Conducted power (dBm)			Target Power + Max. Tolerance (dBm)	MPR Allowed per 3GPP(dB)
					816.5	831.5	846.5		
				Channel	26715	26865	27015		
5	QPSK	1	0	0	22.27	22.12	22.39	22.50	0.5
		1	0	3	22.29	22.18	22.47	22.50	0.5
		1	5	0	22.10	22.33	22.46	22.50	0.5
		1	5	3	22.30	22.29	22.35	22.50	0.5
		3	0	0	22.09	22.19	22.41	22.00	1.0
		3	3	3	22.29	22.26	22.39	22.00	1.0
		6	0	0	21.83	21.78	21.83	21.50	1.5
		6	0	3	21.64	21.89	21.82	21.50	1.5
5	16-QAM	1	0	0	21.71	21.77	21.79	22.50	0.5
		1	0	3	21.62	21.74	21.91	22.50	0.5
		1	4	0	21.59	21.85	21.95	22.50	0.5
		1	4	3	21.81	21.79	21.86	22.50	0.5
		3	0	0	21.73	21.61	21.73	21.50	1.5
		3	2	3	21.74	21.69	21.79	21.50	1.5
		5	0	0	21.72	21.71	21.84	20.50	2.5
		5	0	3	21.65	21.86	21.74	20.50	2.5

LTE Band 26_Cat.M1									
BW(MHz)	Modulation	RB Size	RB Offset	NB Index	Conducted power (dBm)			Target Power + Max. Tolerance (dBm)	MPR Allowed per 3GPP(dB)
Frequency (MHz)					815.5	831.5	847.5		
Channel					26705	26865	27025		
3	QPSK	1	0	0	21.83	21.71	21.74	22.50	0.5
		1	5	1	21.69	21.67	21.70	22.50	0.5
		3	0	0	20.64	20.64	20.96	21.50	1.5
		3	3	1	20.67	20.83	20.71	21.50	1.5
		6	0	0	19.69	19.83	19.81	20.50	2.5
		6	0	1	19.64	19.77	19.97	20.50	2.5
3	16-QAM	1	0	0	20.82	20.68	20.83	21.50	1.5
		1	4	1	20.66	20.60	20.79	21.50	1.5
		3	0	0	19.59	19.72	19.81	20.50	2.5
		3	2	1	19.76	19.79	19.93	20.50	2.5
		5	0	0	19.79	19.62	19.89	20.50	2.5
		5	0	1	19.79	19.89	19.73	20.50	2.5

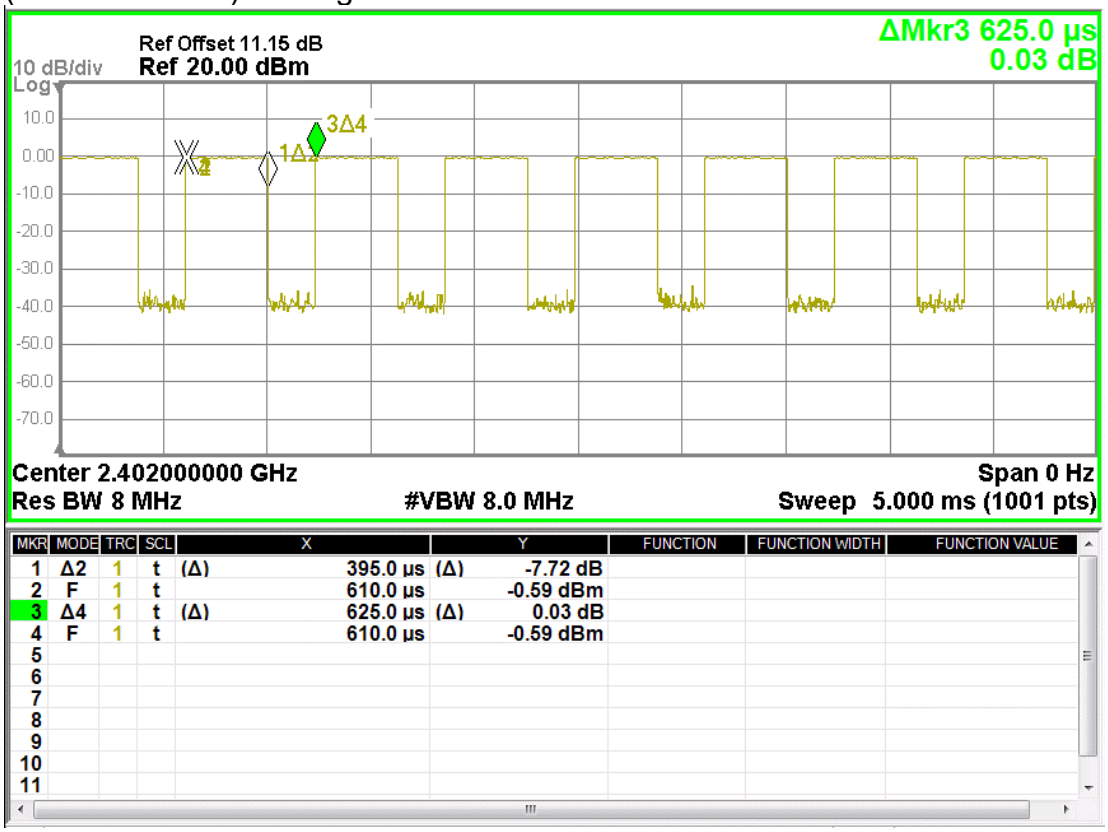
LTE Band 26_Cat.M1									
BW(MHz)	Modulation	RB Size	RB Offset	NB Index	Conducted power (dBm)			Target Power + Max. Tolerance (dBm)	MPR Allowed per 3GPP(dB)
Frequency (MHz)					814.7	831.5	848.3		
Channel					26697	26865	27033		
1.4	QPSK	1	0	0	21.59	21.85	22.00	22.50	0.5
		1	5	0	21.68	21.78	21.78	22.50	0.5
		3	0	0	20.77	20.86	20.80	21.50	1.5
		3	3	0	20.74	20.62	20.85	21.50	1.5
		6	0	0	19.74	19.72	19.90	20.50	2.5
1.4	16-QAM	1	0	0	21.17	21.38	21.33	22.00	1.0
		1	4	0	20.71	20.65	20.71	21.50	1.5
		3	0	0	20.10	20.18	20.47	21.00	2.0
		3	2	0	20.33	20.15	20.39	21.00	2.0
		5	0	0	20.18	20.24	20.40	21.00	2.0

5.3 BLE

Mode	Channel	Frequency (MHz)	GFSK	
			Max. Rated Avg.Power + Max. Tolerance (dBm)	Average Output Power (dBm)
BLE_1M	CH 00	2402	4	3.99
	CH 20	2442		3.94
	CH 39	2480		3.66

Mode	Channel	Frequency (MHz)	GFSK	
			Max. Rated Avg.Power + Max. Tolerance (dBm)	Average Output Power (dBm)
BLE_2M	CH 00	2402	4	3.96
	CH 20	2442		3.89
	CH 39	2480		3.62

BLE_1M duty
(395/626=0.631) Scaling Factor=1.585



MKR	MODE	TRC	SCL	X		Y		FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	Δ2	1	t	(Δ)	395.0 µs	(Δ)	-7.72 dB			
2	F	1	t		610.0 µs		-0.59 dBm			
3	Δ4	1	t	(Δ)	625.0 µs	(Δ)	0.03 dB			
4	F	1	t		610.0 µs		-0.59 dBm			
5										
6										
7										
8										
9										
10										
11										

6 SUMMARY OF RESULTS

6.1 Decision rules

Reported measurement data comply with Test Methodology in section 1.1.
Determining compliance shall be based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty.

6.2 Summary of SAR Results

NB-IoT

Mode	Sub-carrier spacing (KHz)	Modulation	Ntones	Position	Distance (mm)	CH	Freq. (MHz)	Max. Rated Avg. Power + Max. Tolerance (dBm)	Measured Avg. Power (dBm)	Scaling	Averaged SAR over 1g (W/kg)		ID
											Measured	Reported	
LTE Band 26_FCC	15	QPSK	1@0	Top view	15	27039	848.9	23.00	22.35	116.14%	0.027	0.031	-
LTE Band 26_FCC			1@11	Top view	15	27039	848.9	23.00	22.20	120.23%	0.021	0.025	-
LTE Band 26_FCC			3@3	Top view	15	26865	831.5	23.00	22.21	119.95%	0.023	0.028	-
LTE Band 26_FCC			1@0	Edge 1 view	15	27039	848.9	23.00	22.35	116.14%	0.064	0.074	-
LTE Band 26_FCC			1@11	Edge 1 view	15	27039	848.9	23.00	22.20	120.23%	0.055	0.066	-
LTE Band 26_FCC			3@3	Edge 1 view	15	26865	831.5	23.00	22.21	119.95%	0.060	0.072	-
LTE Band 26_FCC			1@0	Edge 2 view	15	27039	848.9	23.00	22.35	116.14%	0.067	0.078	-
LTE Band 26_FCC			1@11	Edge 2 view	15	27039	848.9	23.00	22.20	120.23%	0.061	0.073	-
LTE Band 26_FCC			3@3	Edge 2 view	15	26865	831.5	23.00	22.21	119.95%	0.062	0.074	-
LTE Band 26_FCC			1@0	Bottom view	15	26691	814.1	23.00	22.18	120.78%	0.312	0.377	-
LTE Band 26_FCC			1@0	Bottom view	15	26865	831.5	23.00	22.27	118.30%	0.307	0.363	-
LTE Band 26_FCC			1@0	Bottom view	15	27039	848.9	23.00	22.35	116.14%	0.327	0.380	001
LTE Band 26_FCC			1@11	Bottom view	15	27039	848.9	23.00	22.20	120.23%	0.311	0.374	-
LTE Band 26_FCC			3@3	Bottom view	15	26865	831.5	23.00	22.21	119.95%	0.302	0.362	-

CAT.M1

Mode	Bandwidth (MHz)	Modulation	RB Size	RB start	Index	Position	Distance (mm)	CH	Freq. (MHz)	Max. Rated Avg. Power + Max. Tolerance (dBm)	Measured Avg. Power (dBm)	Scaling	Averaged SAR over 1g (W/kg)		ID
													Measured	Reported	
LTE Band 26_FCC	15MHz	QPSK	1	0	0	Top view	15	26965	841.5	23.00	22.58	110.15%	0.025	0.028	-
LTE Band 26_FCC			3	0	0	Top view	15	26965	841.5	23.00	22.32	116.95%	0.019	0.022	-
LTE Band 26_FCC			1	0	0	Edge 1 view	15	26965	841.5	23.00	22.58	110.15%	0.084	0.093	-
LTE Band 26_FCC			3	0	0	Edge 1 view	15	26965	841.5	23.00	22.32	116.95%	0.080	0.094	-
LTE Band 26_FCC			1	0	0	Edge 2 view	15	26965	841.5	23.00	22.58	110.15%	0.075	0.083	-
LTE Band 26_FCC			3	0	0	Edge 2 view	15	26965	841.5	23.00	22.32	116.95%	0.068	0.080	-
LTE Band 26_FCC			1	0	0	Bottom view	15	26765	821.5	23.00	22.37	115.61%	0.428	0.495	-
LTE Band 26_FCC			1	0	0	Bottom view	15	26865	831.5	23.00	22.41	114.55%	0.413	0.473	-
LTE Band 26_FCC			1	0	0	Bottom view	15	26965	841.5	23.00	22.58	110.15%	0.453	0.499	002
LTE Band 26_FCC			3	0	0	Bottom view	15	26965	841.5	23.00	22.32	116.95%	0.398	0.465	-

BLE

Mode	Position	Distance (mm)	CH	Freq. (MHz)	Max. Rated Avg. Power + Max. Tolerance (dBm)	Measured Avg. Power (dBm)	Duty cycle scaling	Power scaling	Averaged SAR over 1g (W/kg)		ID
									Measured	Reported	
BLE_1M	Top view	15	0	2402	4.00	3.99	1.59	100.23%	0.001	0.002	-
BLE_1M	Edge 1 view	15	0	2402	4.00	3.99	1.59	100.23%	0.008	0.013	-
BLE_1M	Edge 2 view	15	0	2402	4.00	3.99	1.59	100.23%	0.003	0.005	-
BLE_1M	Bottom view	15	0	2402	4.00	3.99	1.59	100.23%	0.036	0.057	003

Note:
Reported SAR = measured SAR * Power scaling * Duty cycle scaling

6.3 Reporting statements of conformity

The conformity statement in this report is based solely on the test results, measurement uncertainty is excluded.

6.4 Conclusion

The device is compliant because all the standalone results are less than their corresponding criteria.

7 SIMULTANEOUS TRANSMISSION ANALYSIS

7.1 Simultaneous Transmission Scenarios:

Simultaneous Transmit Configurations	Body
WWAN+BLE	Yes

7.2 Estimated SAR calculation

According to KDB447498 D01v06 – When standalone SAR test exclusion applies to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to following to determine simultaneous transmission SAR test exclusion:

$$\text{Estimated SAR} = \frac{\text{Max. tune up power (mW)}}{\text{Min. test separation distance(mm)}} \times \frac{\sqrt{\text{f(GHz)}}}{7.5}$$

If the minimum test separation distance is < 5mm, a distance of 5mm is used for estimated SAR calculation. When the test separation distance is >50mm, the 0.4W/kg is used for SAR-1g.

7.3 SPLSR evaluation and analysis

Per KDB447498D01, when the sum of SAR is larger than the limit, SAR test exclusion is determined by the SAR sum to peak location separation ratio(SPLSR).

The simultaneous transmitting antennas in each operating mode and exposure condition combination must be considered one pair at a time to determine the SAR to peak location separation ratio to qualify for test exclusion.

The ratio is determined by **(SAR1 + SAR2)^1.5/Ri**, rounded to two decimal digits, and must be **≤ 0.04** for all antenna pairs in the configuration to qualify for 1-g SAR test exclusion.

SAR1 and SAR2 are the highest reported or estimated SAR for each antenna in the pair, and Ri is the separation distance between the peak SAR locations for the antenna pair in mm.

When standalone test exclusion applies, SAR is estimated; the peak location is assumed to be at the feed-point or geometric center of the antenna.

Simultaneous Transmission Combination

			FCC Reported SAR		Scenario 1
	Exposure Position		1	6	1+6
			WWAN NB-IoT	BLE	Summed
			1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)
LTE Band 26_FCC	Top view	15	0.031	0.002	**0.033**
	Edge 1 view	15	0.074	0.013	**0.087**
	Edge 2 view	15	0.078	0.005	**0.083**
	Bottom view	15	0.380	0.057	**0.437**

			FCC Reported SAR		Scenario 1
	Exposure Position		1	6	1+6
			WWAN CAT.M1	BLE	Summed
			1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)
LTE Band 26_FCC	Top view	15	0.028	0.002	**0.030**
	Edge 1 view	15	0.094	0.013	**0.107**
	Edge 2 view	15	0.083	0.005	**0.088**
	Bottom view	15	0.499	0.057	**0.556**

7.4 Conclusion

The simultaneous transmission is compliant because both SAR sum and/or SPLSR are less than their corresponding criteria.

8 INSTRUMENTS LIST

SAR Test Site: SAR_3					
Manufacturer	**Device**	**Type**	**Serial number**	**Date of last calibration**	**Date of next calibration**
SPEAG	Dosimetric E-Field Probe	EX3DV4	7686	Oct/05/2021	Oct/04/2022
SPEAG	System Validation Dipole	D835V2	4d063	Oct/18/2021	Oct/17/2022
SPEAG	System Validation Dipole	D2450V2	727	Apr/25/2022	Apr/24/2023
SPEAG	Data acquisition Electronics	DAE4	1665	Feb/28/2022	Feb/27/2023
SPEAG	Software	DASY 52 V52.10.4.1527	N/A	Calibration not required	Calibration not required
SPEAG	Phantom	ELI	N/A	Calibration not required	Calibration not required
SPEAG	Dielectric Assessment Kit	DAKS-3.5	1053	Feb/28/2022	Feb/27/2023
Agilent	Dual-directional coupler	772D	MY52180142	Nov/02/2021	Nov/01/2022
Agilent	Dual-directional coupler	778D	MY52180302	Oct/29/2021	Oct/28/2022
EMCI	Amplifier	ZHL-42	980189	Calibration not required	Calibration not required
EMCI	Amplifier	ZVE-8G	980190	Calibration not required	Calibration not required
R&S	MXG Analog Signal Generator	SMB100A03	182996	Dec/08/2021	Dec/07/2022
R&S	Power Meter	NRX	102191	Jan/22/2022	Jan/21/2023
R&S	Power Sensor	NRP18S	101358	Jan/22/2022	Jan/21/2023
R&S	Power Sensor	NRP18S	109065	Oct/12/2021	Oct/11/2022
Aniritsu	Radio Communication Test	MT8821C	6262044739	Nov/29/2021	Nov/28/2022
LKM	Digital thermometer	DTM3000	EC14010603	Nov/09/2021	Nov/08/2022
TECPEL	Digital thermometer	DTM-303A	TP190085	Jan/14/2022	Jan/13/2023

9 UNCERTAINTY BUDGET

Measurement Uncertainty evaluation template for DUT SAR test (0.3-3G)

A	c	D	e		f	g	h=c * f / e	i=c * g / e	k
Source of Uncertainty	Tolerance/ Uncertainty	Probability Distributio	Div	Div Value	ci (1g)	ci (10g)	Standard uncertainty	Standard uncertainty	vi, or Veff
Measurement system									
Probe calibration	6.00%	N	1	1	1	1	6.00%	6.00%	∞
Isotropy , Axial	3.50%	R	√3	1.732	1	1	2.02%	2.02%	∞
Isotropy, Hemispherical	9.60%	R	√3	1.732	1	1	5.54%	5.54%	∞
Modulation Response	2.40%	R	√3	1.732	1	1	1.40%	1.40%	∞
Boundary Effect	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Linearity	4.70%	R	√3	1.732	1	1	2.71%	2.71%	∞
Detection Limits	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Readout Electronics	0.30%	N	1	1	1	1	0.30%	0.30%	∞
Response time	0.80%	R	√3	1.732	1	1	0.46%	0.46%	∞
Integration Time	2.60%	R	√3	1.732	1	1	1.50%	1.50%	∞
Measurement drift (class A evaluation)	1.75%	R	√3	1.732	1	1	1.01%	1.01%	∞
RF ambient condition - noise	3.00%	R	√3	1.732	1	1	1.73%	1.73%	∞
RF ambient conditions - reflections	3.00%	R	√3	1.732	1	1	1.73%	1.73%	∞
Probe positioner Mechanical restrictions	0.40%	R	√3	1.732	1	1	0.23%	0.23%	∞
Probe Positioning with respect to phantom shell	2.90%	R	√3	1.732	1	1	1.67%	1.67%	∞
Post-processing	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Max SAR Eval	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Test Sample related									
Test sample positioning	2.90%	N	1	1	1	1	2.90%	2.90%	M-1
Device Holder Uncertainty	3.60%	N	1	1	1	1	3.60%	3.60%	M-1
Drift of output power	5.00%	R	√3	1.732	1	1	2.89%	2.89%	∞
Phantom and Setup									
Phantom Uncertainty	4.00%	R	√3	1.732	1	1	2.31%	2.31%	∞
Liquid permittivity (mea.)	4.71%	N	1	1	0.64	0.43	3.01%	2.03%	M
Liquid Conductivity (mea.)	4.67%	N	1	1	0.6	0.49	2.80%	2.29%	M
Combined standard uncertainty		RSS					12.14%	11.81%	
Expant uncertainty (95% confidence interval), K=2							24.27%	23.62%	

10 SAR MEASUREMENT RESULTS

Date: 2022/8/9

ID: 001
Report No. :TESA2207000226ES
LTE Band 26 (SCS 15kHz)_Body_Bottom view_CH 27039_QPSK_1-0_15mm

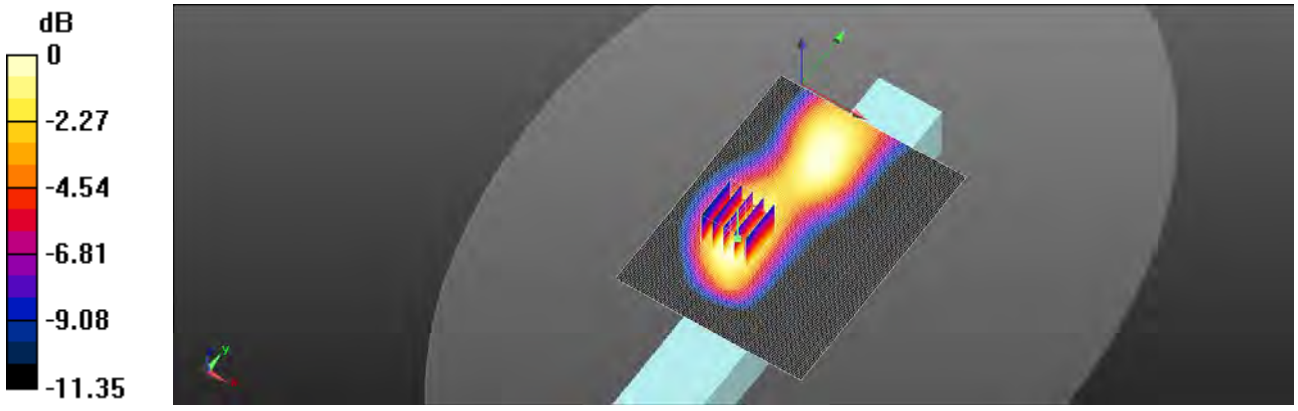
Communication System: LTE NB-IoT; Frequency: 848.9 MHz; Duty cycle= 1:1
Medium parameters used: f = 848.9 MHz; σ = 0.941 S/m; ε_r = 42.504; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.4°C; Liquid temperature: 22.7℃

DASY5 Configuration:

- Probe: EX3DV4 - SN7686; ConvF(10.36, 10.36, 10.36); Calibrated: 2021/10/05
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1665; Calibrated: 2022/02/28
- Phantom: ELI
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Area Scan (91x121x1): Interpolated grid: dx=15 mm, dy=15 mm
Maximum value of SAR (interpolated) = 0.408 W/kg

Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 5.665 V/m; Power Drift = 0.14 dB
Peak SAR (extrapolated) = 0.461 W/kg
SAR(1 g) = 0.327 W/kg; SAR(10 g) = 0.223 W/kg
Smallest distance from peaks to all points 3 dB below = 18.2 mm
Ratio of SAR at M2 to SAR at M1 = 71.3%
Maximum value of SAR (measured) = 0.401 W/kg



0 dB = 0.401 W/kg = -3.97 dBW/kg

Date: 2022/8/9

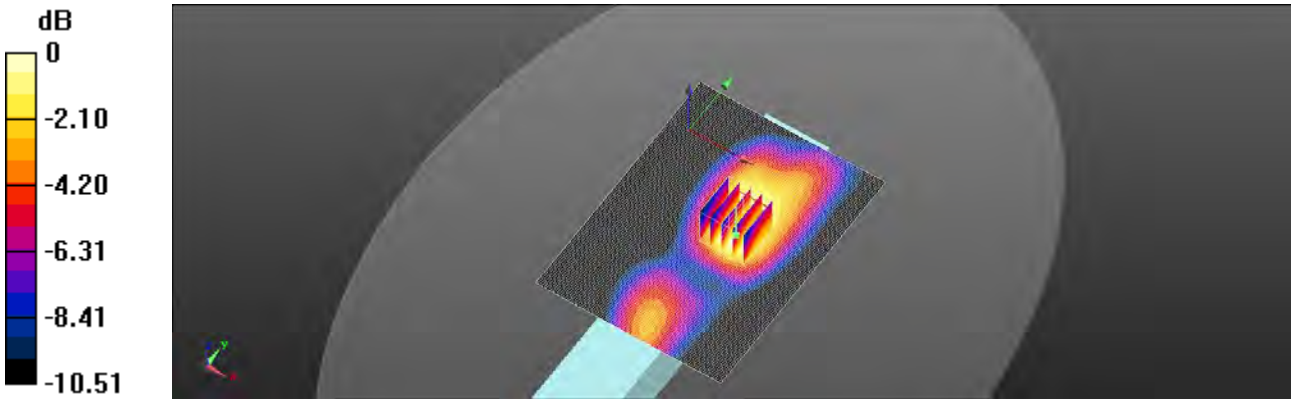
ID: 002
Report No. :TESA2207000226ES
LTE Band 26 (15MHz)_Body_Bottom view_CH 26965_QPSK_1-0_Index 0_15mm
Communication System: LTE; Frequency: 841.5 MHz; Duty cycle= 1:1
Medium parameters used: f = 841.5 MHz; σ = 0.939 S/m; ε_r = 42.529; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.4°C; Liquid temperature: 22.7℃

DASY5 Configuration:

- Probe: EX3DV4 - SN7686; ConvF(10.36, 10.36, 10.36); Calibrated: 2021/10/05
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1665; Calibrated: 2022/02/28
- Phantom: ELI
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Area Scan (81x121x1): Interpolated grid: dx=15 mm, dy=15 mm
Maximum value of SAR (interpolated) = 0.562 W/kg

Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 5.735 V/m; Power Drift = 0.12 dB
Peak SAR (extrapolated) = 0.620 W/kg
SAR(1 g) = 0.453 W/kg; SAR(10 g) = 0.310 W/kg
Smallest distance from peaks to all points 3 dB below = 19.3 mm
Ratio of SAR at M2 to SAR at M1 = 73.8%
Maximum value of SAR (measured) = 0.546 W/kg



0 dB = 0.546 W/kg = -2.63 dBW/kg

Date: 2022/8/12

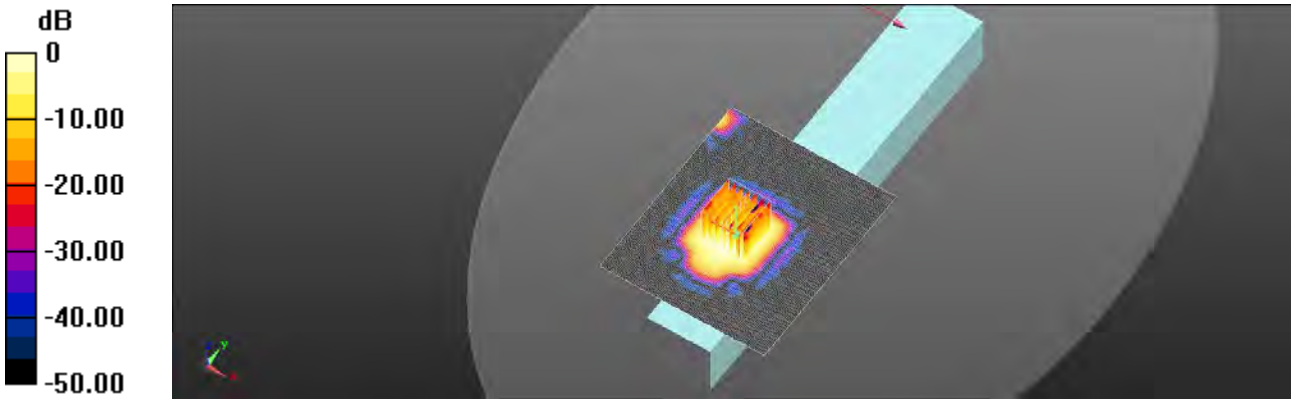
ID: 003
Report No. :TESA2207000226ES
Bluetooth Low Energy_Body_Bottom view_CH 0_15mm
Communication System: Bluetooth Low Energy; Frequency: 2402 MHz;Duty Cycle: 1:1.585
Medium parameters used: f = 2402 MHz; σ = 1.786 S/m; ε_r = 41.131; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.4°C; Liquid temperature: 22.7℃

DASY5 Configuration:

- Probe: EX3DV4 - SN7686; ConvF(8.32, 8.32, 8.32); Calibrated: 2021/10/05
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1665; Calibrated: 2022/02/28
- Phantom: ELI
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Area Scan (101x121x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 0.0539 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 6.546 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 0.0690 W/kg
SAR(1 g) = 0.036 W/kg; SAR(10 g) = 0.017 W/kg
Smallest distance from peaks to all points 3 dB below = 6 mm
Ratio of SAR at M2 to SAR at M1 = 53.6%
Maximum value of SAR (measured) = 0.0512 W/kg



0 dB = 0.0512 W/kg = -12.91 dBW/kg

11 SAR SYSTEM CHECK RESULTS

Date: 2022/8/9

Report No. :TESA2207000226ES

Dipole 835 MHz_SN:4d063

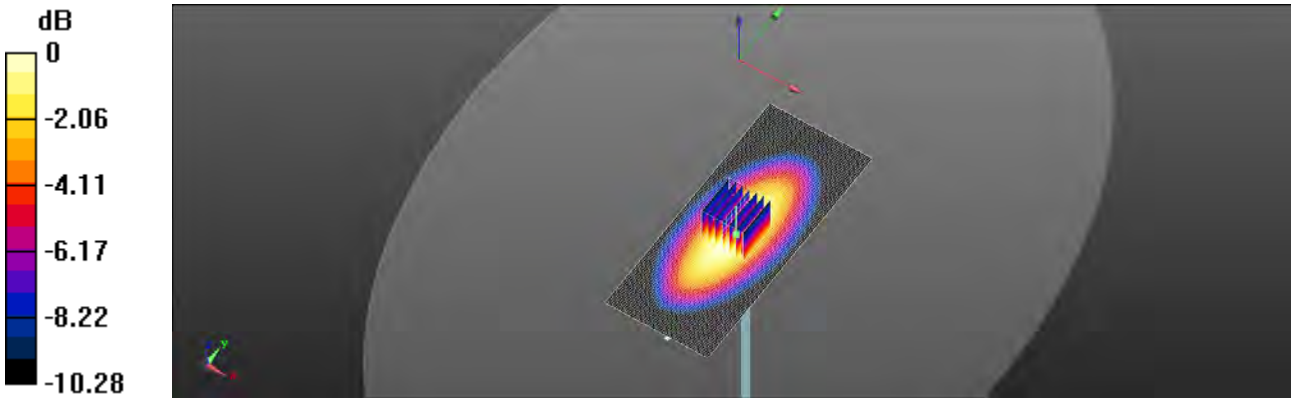
Communication System: CW; Frequency: 835 MHz; Duty cycle= 1:1
Medium parameters used: f = 835 MHz; σ = 0.942 S/m; ε_r = 42.129; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.4°C; Liquid temperature: 22.7℃

DASY5 Configuration:

- Probe: EX3DV4 - SN7686; ConvF(10.36, 10.36, 10.36); Calibrated: 2021/10/05
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1665; Calibrated: 2022/02/28
- Phantom: ELI
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Area Scan (51x121x1): Interpolated grid: dx=15 mm, dy=15 mm
Maximum value of SAR (interpolated) = 2.87 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 56.89 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 3.43 W/kg
SAR(1 g) = 2.31 W/kg; SAR(10 g) = 1.52 W/kg
Smallest distance from peaks to all points 3 dB below = 18 mm
Ratio of SAR at M2 to SAR at M1 = 67.6%
Maximum value of SAR (measured) = 2.92 W/kg



0 dB = 2.92 W/kg = 4.66 dBW/kg

Date: 2022/8/12

Report No. :TESA2207000226ES

Dipole 2450 MHz_SN:727

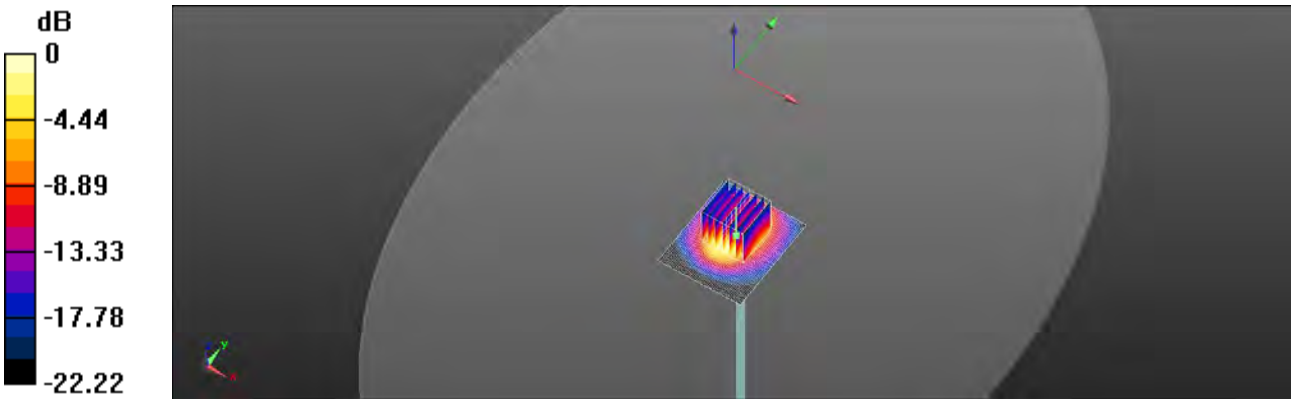
Communication System: CW; Frequency: 2450 MHz;Duty Cycle: 1:1
Medium parameters used: f = 2450 MHz; σ = 1.797 S/m; ε_r = 41.048; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.4°C; Liquid temperature: 22.7℃

DASY5 Configuration:

- Probe: EX3DV4 - SN7686; ConvF(8.32, 8.32, 8.32); Calibrated: 2021/10/05
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1665; Calibrated: 2022/02/28
- Phantom: ELI
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Area Scan (51x61x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 21.9 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 99.04 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 27.5 W/kg
SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.18 W/kg
Smallest distance from peaks to all points 3 dB below = 9.2 mm
Ratio of SAR at M2 to SAR at M1 = 49.1%
Maximum value of SAR (measured) = 20.2 W/kg



0 dB = 20.2 W/kg = 13.06 dBW/kg

12 APPENDIXES

Refer to separated files for the following appendixes.

12.1 SAR_Appendix A Photographs

12.2 SAR_Appendix B DAE & Probe Cal. Certificate

12.3 SAR_Appendix C Phantom Description & Dipole Cal. Certificate

- End of report -