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Report On

Specific Absorption Rate Testing of the Vesper Marine Marlin Handset

Covering FCC 47CFR 2.1093, RSS 102 Issue 5 and related documents.

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REPORT ON

Specific Absorption Rate Testing of the Vesper Marine Marlin Handset

Document 78943820 Report 03 Issue 2

June 2020

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11 June 2020

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SECTION 1

REPORT SUMMARY

Specific Absorption Rate Testing of the
Vesper Marine Marlin Handset

1.1 REPORT MODIFICATION RECORD

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	06 February 2020
2	FCC ID and IC ID are incorrect	11 June 2020

1.2 INTRODUCTION

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

Objective	To perform Specific Absorption Rate Testing to determine the Equipment Under Test's (EUT's) compliance with the requirements specified of KDB 447498 D01 v06 General RF Exposure Guidance, for the series of tests carried out.
Applicant	Vesper Marine
Manufacturer	Vesper Marine
Manufacturing Description	Cortex Handset
Model Number	TUVH1_3
Serial/IMEI Number(s)	Hi.0000000C
Number of Samples Tested	1
Hardware Version	V1.0
Software Version	V1.0
Battery Cell Manufacturer	General Electronics Technology Co, Ltd
Battery Model Number	GEB 654060
Test Specification/Issue/Date	KDB 447498 D01 v06 General RF Exposure Guidance
Order Number	13975
Date of Receipt of EUT	26-Sep-2019
Start of Test	28-Sep-2019
Finish of Test	28-Oct-2019
Related Document(s)	FCC 47CFR 2.1093: 2015 KDB 865664 – D01 v01r04 KDB 865664 – D02 v01r02 KDB 643646 – D04 v01r03 KDB 248227 – D01 v02r02 IEEE 1528-2013 RSS 102 Issue 5
Name of Engineer(s)	Mohammud Mohammud Stephen Dodd

1.3 BRIEF SUMMARY OF RESULTS

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

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

Max 1 g SAR (W/kg) Front of Face	0.003 (Measured)	**0.01** (Scaled)
The maximum 1 g volume averaged SAR level measured for all the tests performed did not exceed the limits for General Population/Uncontrolled Exposure (W/kg) Partial Body of 1.6 W/kg.		

The maximum 10 g volume averaged stand-alone SAR found during this Assessment:

Max 10 g SAR (W/kg) Extremity (Hands)	0.06 (Measured)	**0.07** (Scaled)
The maximum 10 g volume averaged SAR level measured for all the tests performed did not exceed the limits for General Population/Uncontrolled Exposure (W/kg) Partial Body of 4.0 W/kg.		

1.4 TEST RESULTS SUMMARY

1.4.1 System Performance / Validation Check Results

Prior to formal testing being performed a System Check was performed in accordance with KDB 865664 and the results were compared against published data in Standard IEEE 1528-2013. The following results were obtained: -

System performance / Validation results

Date	Frequency (MHz)	Max 1 g SAR (W/kg) *	Percentage Drift on Reference
29/09/2019	2450 MHz	53.74	2.56
28/10/2019	2450 MHz	53.35	4.20

*Normalised to a forward power of 1W

1.4.2 Results Summary Tables

WLAN 2450 MHz 802.11b 20 MHz 1 Mbps
Front Of Face Specific Absorbtion Rate (Maximum SAR) 1 g Results

Test Position	Channel Number	Frequency (MHz)	Measured Average Power (dBm)	Tune Up (dBm)	SAR Scan Type	Measured 1 g SAR (W/kg)	Scaled 1 g SAR (W/kg)	Scan Figure Number
25 mm Front Face	1	2412	18.6	19.0	Full	0.003	0.003	2
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1 g) KDB248227 D01 v02 - Testing was not required for OFDM as per Section 5.2.2								

WLAN 2450 MHz 802.11b 20 MHz 1 Mbps
Extremity Specific Absorbtion Rate (Maximum SAR) 10 g Results

Test Position	Channel Number	Frequency (MHz)	Measured Average Power (dBm)	Tune Up (dBm)	SAR Scan Type	Measured 10 g SAR (W/kg)	Scaled 10 g SAR (W/kg)	Scan Figure Number
0 mm Front Facing	1	2412	18.6	19.0	Fast	0.02	0.02	3
0 mm Rear Facing	1	2412	18.6	19.0	Fast	0.06	0.06	4
0 mm Left Edge	1	2412	18.6	19.0	Fast	0.01	0.01	5
0 mm Right Edge	1	2412	18.6	19.0	Fast	0.01	0.01	6
0 mm Top Edge	1	2412	18.6	19.0	Fast	0.03	0.03	7
0 mm Rear Face	1	2412	18.6	19.0	Fast	0.06	**0.07**	8
Limit for General Population (Uncontrolled Exposure) Extremity 4.0 W/kg (10 g) KDB248227 D01 v02 - Testing was not required for OFDM as per Section 5.2.2 KDB248227 D01 v02 - Only one position was tested with a Full scan as per Section 5.1.1								

1.4.3 Standalone SAR Test Exclusion Considerations (KDB 447498 D01)

The 1 g SAR Test exclusion thresholds for 100 MHz to 6 GHz *test separation distances* ≤ 50 mm are determined by:
[(*max power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)] [√f ($_{GHz}$)]* ≤ 3.0, where

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

RAT & Band	Frequency (MHz)	Power (dBm)	Power (mW)	Test Position	Distance (mm)	Threshold	Test Exclusion
WLAN - 2.4 GHz	2462	19.0	79.43	Front Of face	25	24.9	No

The 10 g SAR Test exclusion thresholds for 100 MHz to 6 GHz *test separation distances* ≤ 50 mm are determined by:
[(*max power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)] [√f ($_{GHz}$)]* ≤ 7.5, where

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

RAT & Band	Frequency (MHz)	Power (dBm)	Power (mW)	Test Position	Distance (mm)	Threshold	Test Exclusion
WLAN - 2.4 GHz	2462	19.0	79.43	Front Of face	5	24.9	No

1.4.4 Technical Description

The equipment under test (EUT) was a Vesper Marine Marlin Handset. A full technical description can be found in the manufacturer's documentation.

1.4.5 Test Configuration and Modes of Operation

The testing was performed with an integral battery supplied and manufactured by General Electronics Technology CO, Ltd. The battery was fully charged before each measurement.

There are two variants of the Marlin Handset, one of which is tethered, the other which is fully Wireless. The EUT used for SAR testing was the tethered variant, where the cable is connected to the Marlin Pod in the real time use of the device. This cable would be suspended in free space between the Handset and the Pod away from the human body, therefore was not positioned against the SAR phantom for testing.

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

For extremity SAR, testing was performed on the channel with the highest measured output power, on the front, rear, top, left and right surface of the EUT, for the position which yielded the highest SAR, the top and bottom channel were also assessed for SAR at a 0 mm separation distance.

For Front of Face SAR, testing was performed on the channel with the highest measured output power at a 25 mm separation distance between the front face of the EUT and the phantom.

Conducted power measurements were performed on the device under test and the measured SAR results were power scaled to the maximum declared tune-up level.

SAR testing was performed on the 802.11b 1Mbps transmission mode. This was deemed as the worst-case mode as it yielded the highest measured conducted output power.

Fast SAR testing was used as a means of test time reduction.

The Elliptical Flat Phantom dimensions are 600 mm major axis and 400 mm minor axis with a shell thickness of 2 mm. The phantom was filled to a minimum depth of 150 mm with the appropriate body simulant liquid. The dielectric properties were measured and found to be in accordance with the requirements specified in KDB 865664 D01

Included in this report are descriptions of the test method; the equipment used and an analysis of the test uncertainties applicable and diagrams indicating the locations of maximum SAR for each test position along with photographs indicating the positioning of the handset against the body as appropriate.

1.5 FCC POWER MEASUREMENTS

1.5.1 Method

Conducted power measurements were made using a power meter.

1.5.2 Conducted Power Measurements

WLAN 2450 MHz

Mode	Frequency (MHz)	Data Rate	Measured Power (dBm))
802.11b	2412	1	**18.6**
802.11b	2437	1	18.4
802.11b	2462	1	18.0
802.11b	2412	2	18.5
802.11b	2437	2	18.3
802.11b	2462	2	17.9
802.11b	2412	5	18.2
802.11b	2437	5	18.2
802.11b	2462	5	17.4
802.11b	2412	11	18.0
802.11b	2437	11	17.8
802.11b	2462	11	17.0

Mode	Frequency (MHz)	Data Rate	Measured Power (dBm))
802.11g	2412	6	10.7
802.11g	2437	6	17.0
802.11g	2462	6	9.2
802.11g	2412	9	10.7
802.11g	2437	9	16.8
802.11g	2462	9	9.0
802.11g	2412	12	10.3
802.11g	2437	12	16.5
802.11g	2462	12	8.7
802.11g	2412	18	9.9
802.11g	2437	18	16.2
802.11g	2462	18	8.3
802.11g	2412	24	9.5
802.11g	2437	24	15.8
802.11g	2462	24	7.9
802.11g	2412	36	9.6
802.11g	2437	36	15.8
802.11g	2462	36	8.0
802.11g	2412	48	9.0
802.11g	2437	48	15.4
802.11g	2462	48	7.6
802.11g	2412	54	8.8
802.11g	2437	54	14.7
802.11g	2462	54	7.4

Mode	Frequency (MHz)	MCS INDEX	Measured Power (dBm))
802.11n	2412	MCS0	10.8
802.11n	2437	MCS0	17.1
802.11n	2462	MCS0	9.2
802.11n	2412	MCS1	10.4
802.11n	2437	MCS1	16.7
802.11n	2462	MCS1	8.8
802.11n	2412	MCS2	10.0
802.11n	2437	MCS2	16.4
802.11n	2462	MCS2	8.4
802.11n	2412	MCS3	9.6
802.11n	2437	MCS3	15.9
802.11n	2462	MCS3	8.1
802.11n	2412	MCS4	9.0
802.11n	2437	MCS4	15.4
802.11n	2462	MCS4	7.5
802.11n	2412	MCS5	8.6
802.11n	2437	MCS5	14.9
802.11n	2462	MCS5	7.0
802.11n	2412	MCS6	8.4
802.11n	2437	MCS6	14.8
802.11n	2462	MCS6	6.8
802.11n	2412	MCS7	8.2
802.11n	2437	MCS7	14.6
802.11n	2462	MCS7	6.6

Maximum declared output power 19.0dBm (802.11b)

SECTION 2

TEST DETAILS

Specific Absorption Rate Testing of the
Vesper Marine Marlin Handset

2.1 DASY5 MEASUREMENT SYSTEM

2.1.1 System Description

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

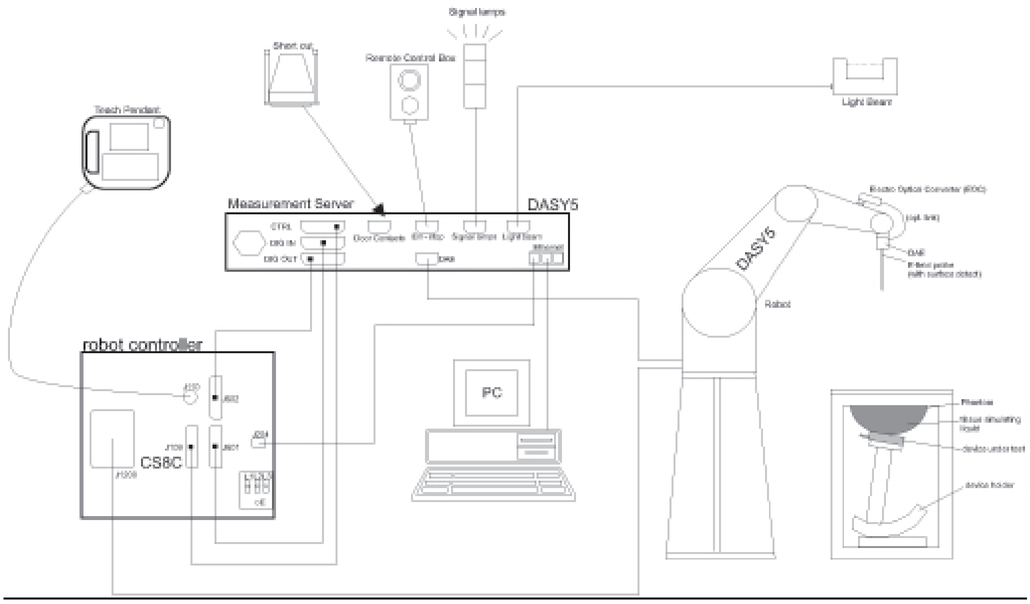

Figure 1 System Description Diagram

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

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

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

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

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

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

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

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

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

2.1.2 Probe Specification

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

2.1.3 Data Acquisition Electronics

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

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

2.1.4 SAR Evaluation Description

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

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

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

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

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

2.1.5 Interpolation, Extrapolation and Detection of Maxima

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

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

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

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

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

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

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

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

In the Zoom Scan, the interpolation function is used to extrapolate the Peak SAR from the lowest measurement points to the inner phantom surface (the extrapolation distance). The uncertainty increases with the extrapolation distance. To keep the uncertainty within 1% for the 1 g and 10 g cubes, the extrapolation distance should not be larger than 5mm.

2.1.6 Averaging and Determination of Spatial Peak SAR

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

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

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

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

2.2 WLAN 2450 MHz FRONT OF FACE SAR TEST RESULTS

SOFTWARE VERSION:	52.10.2(1495)	**AMBIENT TEMPERATURE:**	22.5 °C
DATE:	29/09/2019	**RELATIVE HUMIDITY:**	50.9 %
PHANTOM:	QD 000 P40 CD	**CONDUCTIVITY:**	1.927 S/m
DUT CONFIGURATION:	802.11b 20 MHz 1Mbps	**RELATIVE PERMITTIVITY:**	53.134
DUT POSITION:	25 mm - Front Face	**LIQUID TEMPERATURE:**	20.6 °C
RAT:	WLAN	**SCAN TYPE:**	Full
FREQUENCY:	2412 MHz	**DRIFT:**	-0.01 dB
MODULATION:	BPSK	**PEAK SAR:**	0.01 W/kg
DUTY CYCLE:	100 %	**SAR (10 g):**	0.00 W/kg

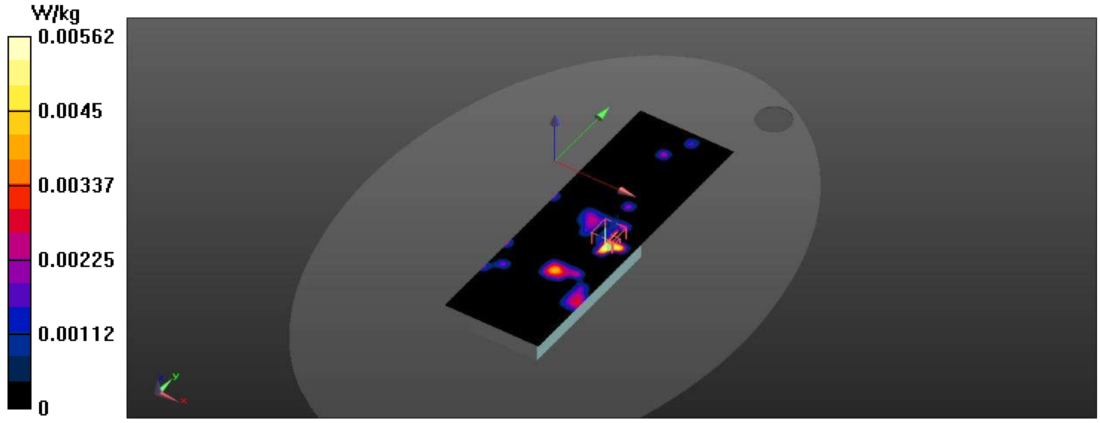

Figure 2: SAR Body Testing Results for the Marlin Handset at 2412 MHz.

2.3 WLAN 2450 MHZ EXTREMITY SAR TEST RESULTS

SOFTWARE VERSION:	52.10.2(1495)	**AMBIENT TEMPERATURE:**	22.1 °C
DATE:	28/10/2019	**RELATIVE HUMIDITY:**	31.5 %
PHANTOM:	QD 000 P40 CD	**CONDUCTIVITY:**	1.984 S/m
DUT CONFIGURATION:	802.11b 20 MHz 1Mbps	**RELATIVE PERMITTIVITY:**	52.557
DUT POSITION:	0 mm - Front Face	**LIQUID TEMPERATURE:**	20.6 °C
RAT:	WLAN	**SCAN TYPE:**	Fast
FREQUENCY:	2412 MHz	**DRIFT:**	-0.03 dB
MODULATION:	BPSK	**PEAK SAR:**	0.07 W/kg
DUTY CYCLE:	100 %	**SAR (10 g):**	0.02 W/kg

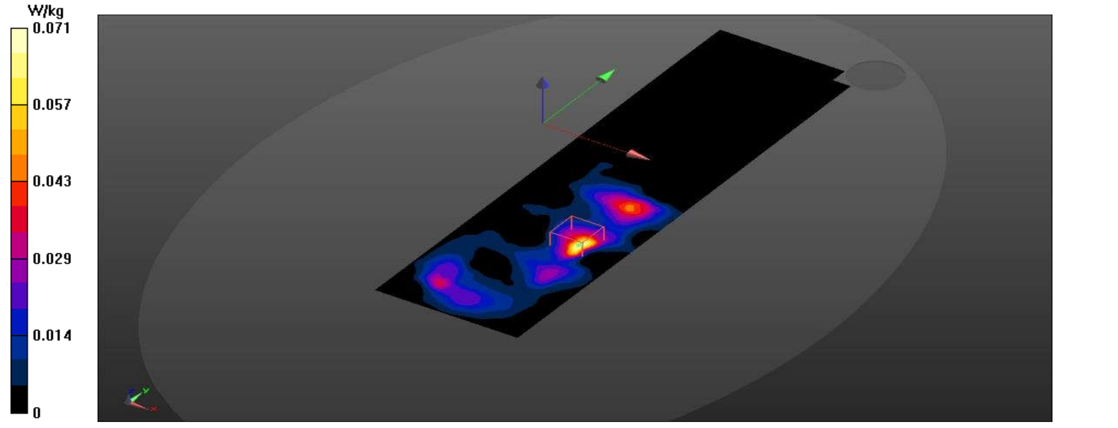

Figure 3: SAR Body Testing Results for the Marlin Handset at 2412 MHz.

SOFTWARE VERSION:	52.10.2(1495)	**AMBIENT TEMPERATURE:**	22.1 °C
DATE:	28/10/2019	**RELATIVE HUMIDITY:**	31.5 %
PHANTOM:	QD 000 P40 CD	**CONDUCTIVITY:**	1.984 S/m
DUT CONFIGURATION:	802.11b 20 MHz 1Mbps	**RELATIVE PERMITTIVITY:**	52.557
DUT POSITION:	0 mm - Rear Face	**LIQUID TEMPERATURE:**	20.6 °C
RAT:	WLAN	**SCAN TYPE:**	Fast
FREQUENCY:	2412 MHz	**DRIFT:**	-0.13 dB
MODULATION:	BPSK	**PEAK SAR:**	0.16 W/kg
DUTY CYCLE:	100 %	**SAR (10 g):**	0.06 W/kg

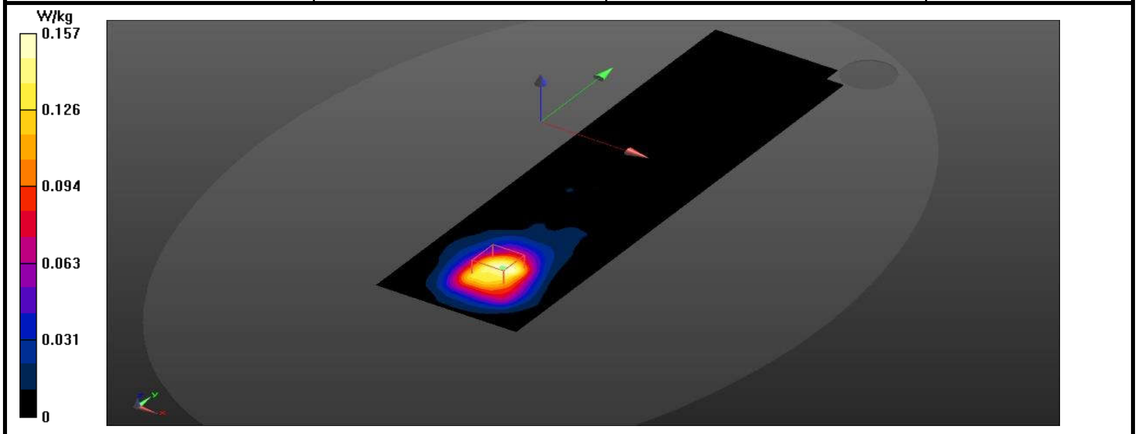

Figure 4: SAR Body Testing Results for the Marlin Handset at 2412 MHz.

SOFTWARE VERSION:	52.10.2(1495)	**AMBIENT TEMPERATURE:**	22.1 °C
DATE:	28/10/2019	**RELATIVE HUMIDITY:**	31.5 %
PHANTOM:	QD 000 P40 CD	**CONDUCTIVITY:**	1.984 S/m
DUT CONFIGURATION:	802.11b 20 MHz 1Mbps	**RELATIVE PERMITTIVITY:**	52.557
DUT POSITION:	0 mm - Left Face	**LIQUID TEMPERATURE:**	20.6 °C
RAT:	WLAN	**SCAN TYPE:**	Fast
FREQUENCY:	2412 MHz	**DRIFT:**	0.12 dB
MODULATION:	BPSK	**PEAK SAR:**	0.04 W/kg
DUTY CYCLE:	100 %	**SAR (10 g):**	0.01 W/kg

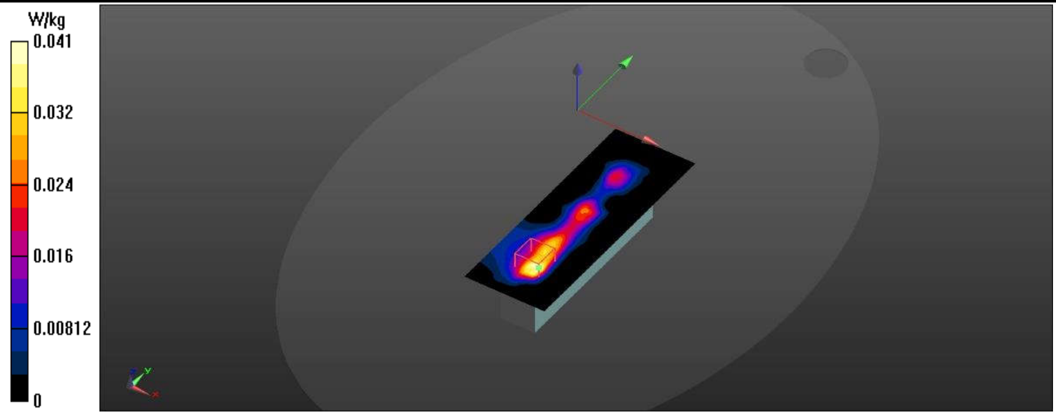

Figure 5: SAR Body Testing Results for the Marlin Handset at 2412 MHz.

SOFTWARE VERSION:	52.10.2(1495)	**AMBIENT TEMPERATURE:**	22.1 °C
DATE:	28/10/2019	**RELATIVE HUMIDITY:**	31.5 %
PHANTOM:	QD 000 P40 CD	**CONDUCTIVITY:**	1.984 S/m
DUT CONFIGURATION:	802.11b 20 MHz 1Mbps	**RELATIVE PERMITTIVITY:**	52.557
DUT POSITION:	0 mm - Right Face	**LIQUID TEMPERATURE:**	20.6 °C
RAT:	WLAN	**SCAN TYPE:**	Fast
FREQUENCY:	2412 MHz	**DRIFT:**	-0.06 dB
MODULATION:	BPSK	**PEAK SAR:**	0.04 W/kg
DUTY CYCLE:	100 %	**SAR (10 g):**	0.01 W/kg

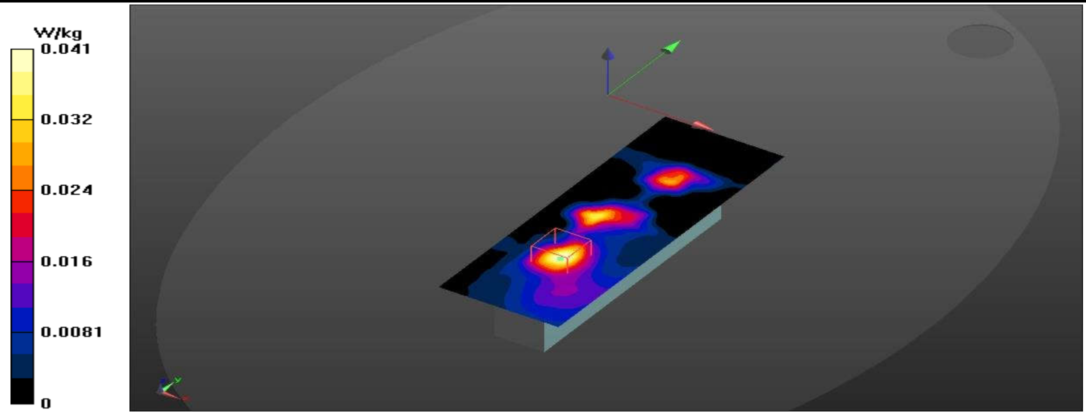

Figure 6: SAR Body Testing Results for the Marlin Handset at 2412 MHz

SOFTWARE VERSION:	52.10.2(1495)	**AMBIENT TEMPERATURE:**	22.1 °C
DATE:	28/10/2019	**RELATIVE HUMIDITY:**	31.5 %
PHANTOM:	QD 000 P40 CD	**CONDUCTIVITY:**	1.984 S/m
DUT CONFIGURATION:	802.11b 20 MHz 1Mbps	**RELATIVE PERMITTIVITY:**	52.557
DUT POSITION:	0 mm - Top Face	**LIQUID TEMPERATURE:**	20.6 °C
RAT:	WLAN	**SCAN TYPE:**	Fast
FREQUENCY:	2412 MHz	**DRIFT:**	-0.19 dB
MODULATION:	BPSK	**PEAK SAR:**	0.10 W/kg
DUTY CYCLE:	100 %	**SAR (10 g):**	0.03 W/kg

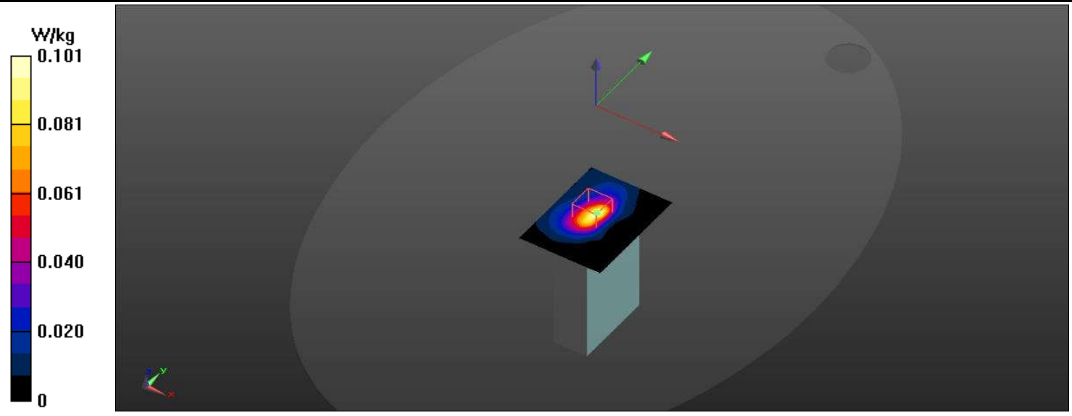

Figure 7: SAR Body Testing Results for the Marlin Handset at 2412 MHz

SOFTWARE VERSION:	52.10.2(1495)	**AMBIENT TEMPERATURE:**	22.1 °C
DATE:	28/10/2019	**RELATIVE HUMIDITY:**	31.5 %
PHANTOM:	QD 000 P40 CD	**CONDUCTIVITY:**	1.984 S/m
DUT CONFIGURATION:	802.11b 20 MHz 1Mbps	**RELATIVE PERMITTIVITY:**	52.557
DUT POSITION:	0 mm - Rear Face	**LIQUID TEMPERATURE:**	20.6 °C
RAT:	WLAN	**SCAN TYPE:**	Full
FREQUENCY:	2412 MHz	**DRIFT:**	-0.19 dB
MODULATION:	BPSK	**PEAK SAR:**	0.18 W/kg
DUTY CYCLE:	100 %	**SAR (10 g):**	0.07 W/kg

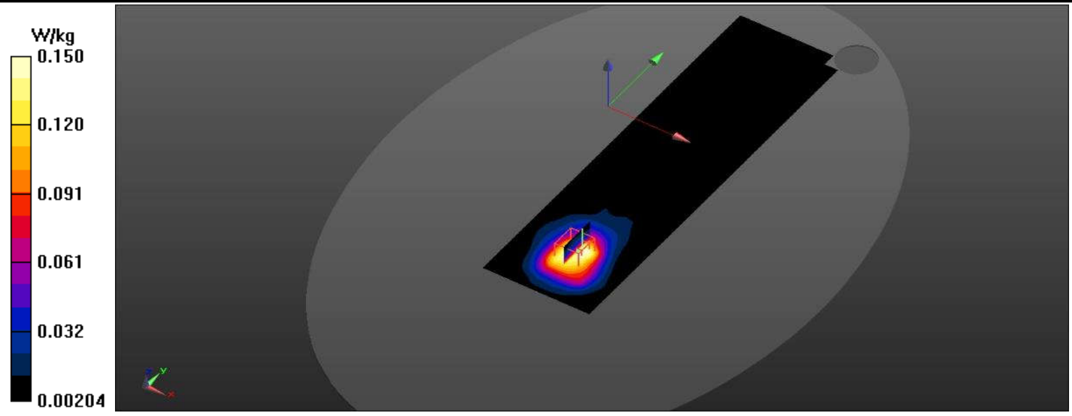

Figure 8: SAR Body Testing Results for the Marlin Handset at 2412 MHz

SECTION 3

TEST EQUIPMENT USED

3.1 TEST EQUIPMENT USED

The following test equipment was used at TÜV SÜD:

Instrument Description	Manufacturer	Model Type	TE Number	Cal Period (months)	Calibration Due Date
Signal Generator	Hewlett Packard	ESG4000A	38	12	06-Jun-2020
10MHz - 2.5GHz, 3W, Amplifier	Vectawave Technology	VTL5400	51	-	TU
Bi-directional Coupler	IndexSar Ltd	7401 (VDC0830-20)	2414	-	TU
Attenuator (30dB, 25W)	Weinschel	46-30-34	2776	12	23-Jul-2020
Power Meter	Rohde & Schwarz	NRVD	2979	12	07-Jun-2020
Hygrometer	Rotronic	I-1000	3068	12	27-Jun-2020
Thermometer	Digitron	T208	64	12	12-Jun-2020
Power Meter	Rohde & Schwarz	NRP	3491	12	11-Oct-2020
Wideband Power Sensor, 50MHz - 18GHz	Rohde & Schwarz	NRP-Z81	3492	12	11-Oct-2020
Power Sensor	Rohde & Schwarz	NRV-Z1	3563	12	07-Jun-2020
SAR phone holder	Speag	n/a	3870	-	TU
Data Acquisition Electronics	Speag	DAE 4 - SD 000 D04 BN	5327	12	07-Jun-2020
Validation Dipole (2450MHz)	Speag	D2450V2	5329	12	07-Jun-2020
Dosimetric SAR Probe	Speag	EX3DV4	5330	12	07-Jun-2020
Body Phantom	Speag	Oval Flat Phantom ELI v8.0	5333	-	TU
Measurement server	Speag	DASY 6 Measurement Server	5337	-	TU
Robot	Speag	TX90 XL Stäubli Robot	5340	-	TU
HBBL	Speag	Batch 3	-	Weekly	01-Nov-2019
MBBL	Speag	Batch 3	-	Weekly	01-Nov-2019

TU - Traceability Unscheduled

3.2 TEST SOFTWARE

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

Instrument	Version Number
DASY system	52.10.2(1495)

3.3 DIELECTRIC PROPERTIES OF SIMULANT LIQUIDS

The fluid properties of the simulant fluids used during routine SAR evaluation meet the dielectric properties required KDB 447498 D01

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

Fluid Type and Frequency	Relative Permittivity Target (ε_r)	Relative Permittivity Measured (ε_r)	Conductivity Target (σ)	Conductivity Measured (σ)	Date	Fluid Temperature °C
HBBL-B3 @ 2450 MHz	39.20	40.75	1.80	1.85	24-09-19	21.7
MBBL-B3 @ 2450 MHz	52.70	52.50	1.95	2.02	25-10-19	19.0

3.4 TEST CONDITIONS

3.4.1 Test Laboratory Conditions

Ambient temperature: Within +15°C to +35°C.
The actual temperature during the testing ranged from 22.1°C to 22.5°C.
The actual humidity during the testing ranged from 31.5% to 50.9% RH.

3.4.2 Test Fluid Temperature Range

Frequency	Body / Head Fluid	Min Temperature °C	Max Temperature °C
2450 MHz	Body	20.6	19.0

3.4.3 SAR Drift

The SAR Drift was within acceptable limits during scans. The maximum SAR Drift was recorded as -0.19 dB.

3.5 MEASUREMENT UNCERTAINTY

Fast SAR Measurements, 300 MHz to 3 GHz

Source of Uncertainty	Uncertainty ± %	Probability distribution	Div	c_i (1 g)	Standard Uncertainty ± % (1 g)	v_i (v_{eff})
Measurement System						
Probe calibration	6.0	N	1.00	0.00	0.0	
Axial Isotropy	4.7	R	1.73	0.70	1.9	Infinity
Hemispherical Isotropy	9.6	R	1.73	0.70	3.9	Infinity
Boundary effect	1.0	R	1.73	1.00	0.6	Infinity
Linearity	4.7	R	1.73	1.00	2.7	Infinity
System Detection limits	1.0	R	1.73	1.00	0.6	Infinity
Modulation response	2.4	R	1.73	1.00	1.4	Infinity
Readout electronics	0.3	N	1.00	0.00	0.0	
Response time	0.8	R	1.73	0.00	0.0	
Integration time	2.6	R	1.73	1.00	1.5	Infinity
RF ambient noise	3.0	R	1.73	1.00	1.7	Infinity
RF ambient reflections	3.0	R	1.73	0.00	0.0	
Probe positioner	0.4	R	1.73	1.00	0.2	Infinity
Probe positioning	2.9	R	1.73	1.00	1.7	Infinity
Spatial x-y-Resolution	10.0	R	1.73	1.00	5.8	Infinity
Fast SAR z-Approximation	7.0	R	1.73	1.00	4.0	Infinity
Test sample related						
Device Positioning	2.9	N	1.00	1.00	2.9	145
Device Holder	3.6	N	1.00	1.00	3.6	5
Input Power and SAR Drift	5.0	R	1.73	1.00	2.9	Infinity
Phantom and Setup						
Phantom uncertainty	6.1	R	1.73	1.00	3.5	Infinity
SAR Correction	1.9	R	1.73	0.00	0.0	
Liquid conductivity Meas.	2.5	R	1.73	0.00	0.0	
Liquid Permittivity Meas.	2.5	R	1.73	0.00	0.0	
Temp. Unc. Conductivity	3.4	R	1.73	0.00	0.0	
Temp. Unc. Permittivity	0.4	R	1.73	0.00	0.0	
Combined Standard Uncertainty		**RSS**			11.4	748
Expanded Standard Uncertainty		**K=2**			22.7	

Full SAR Measurements, 300 MHz to 3 GHz

Source of Uncertainty	Uncertainty ± %	Probability distribution	Div	c_i (1 g)	Standard Uncertainty ± % (1 g)	v_i (v_{eff})
Measurement System						
Probe calibration	6.0	N	1.00	1.00	6.0	Infinity
Axial Isotropy	4.7	R	1.73	0.70	1.9	Infinity
Hemispherical Isotropy	9.6	R	1.73	0.70	3.9	Infinity
Boundary effect	1.0	R	1.73	1.00	0.6	Infinity
Linearity	4.7	R	1.73	1.00	2.7	Infinity
System Detection limits	1.0	R	1.73	1.00	0.6	Infinity
Modulation response	2.4	R	1.73	1.00	1.4	Infinity
Readout electronics	0.3	N	1.00	1.00	0.3	Infinity
Response time	0.8	R	1.73	1.00	0.5	Infinity
Integration time	2.6	R	1.73	1.00	1.5	Infinity
RF ambient noise	3.0	R	1.73	1.00	1.7	Infinity
RF ambient reflections	3.0	R	1.73	1.00	1.7	Infinity
Probe positioner	0.4	R	1.73	1.00	0.2	Infinity
Probe positioning	2.9	R	1.73	1.00	1.7	Infinity
Max SAR Evaluation	2.0	R	1.73	1.00	1.2	Infinity
Test sample related						
Device Positioning	2.9	N	1.00	1.00	2.9	145
Device Holder	3.6	N	1.00	1.00	3.6	5
Input Power and SAR Drift	5.0	R	1.73	1.00	2.9	Infinity
Phantom and Setup						
Phantom uncertainty	6.1	R	1.73	1.00	3.5	Infinity
SAR Correction	1.9	R	1.73	1.00	1.1	Infinity
Liquid conductivity Meas.	2.5	R	1.73	0.78	1.1	Infinity
Liquid Permittivity Meas.	2.5	R	1.73	0.26	0.3	Infinity
Temp. Unc. Conductivity	3.4	R	1.73	0.78	1.5	Infinity
Temp. Unc. Permittivity	0.4	R	1.73	0.23	0.1	Infinity
Combined Standard Uncertainty		**RSS**			11.2	361
Expanded Standard Uncertainty		**K=2**			22.3	