

SAR Test Report

Part 1 of 3

Project Number: 5209337**Quotation Number:** SUW-202308005164**Report Number:** 5209337EMC03**Revision Level:** 0**Client:** Persistent Systems, LLC**Equipment Under Test:** Wave Relay® MANET System**Model Number:** MPU5 with RF-2150 Radio Module**FCC ID:** 2AG3JRF-2150**Applicable Standards:** IEC 62209-1528

47 CFR §§ 2.1093

KDB 447498, KDB 865664, KDB 248227

Report issued on: 21 October 2024**Test Result:** Compliant

FOR THE SCOPE OF ACCREDITATION UNDER CERTIFICATE NUMBER: 3212.01

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Tested / Evaluated by:

A handwritten signature in blue ink, appearing to read 'P. Lorenzo'.

Paul Lorenzo, Senior EMC Technician

Reviewed by:

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1 SUMMARY OF RESULTS

RF Exposure Conditions	General Population/Uncontrolled		Compliance to FCC 2.1093
	Localized SAR 1g (Head and Body)	Localized SAR 10g (Extremities)	
	1.6 W/kg	NA	
			Complies

Equipment Class	Band	Highest SAR values (W/kg)				
		Head		Body		Extremity
		1g	10g	1g	10g	10g
DTS	WLAN 2450-2483.5 MHz	NA	NA	0.545	NA	NA
Simultaneous Results		NA	NA	1.54	NA	NA

2 GENERAL INFORMATION

2.1 CLIENT INFORMATION

Name: Persistent Systems LLC
Address: 601 W 26th St Suite 905
City, State, Zip, Country: New York, NY 10001, USA

2.2 TEST LABORATORY

Name: SGS North America, Inc.
Address: 620 Old Peachtree Road NW, Suite 100
City, State, Zip, Country: Suwanee, GA 30024, USA

2.3 GENERAL INFORMATION OF EUT

Equipment Under Test Wave Relay® MANET System

Host Model Number: MPU5 with RF-2150 Radio Module
Sample ID Number: Radiated: 85093
Conducted: 85093

Frequencies of Operation: WLAN 2.45GHz: 2450 – 2483.5 MHz

Maximum Conducted Power: See Section 2.4 of this report

Battery Model: BT-70716BV-PS
Antenna Chains 1 and 3 Model: Omni Ant 2005, ½ wave dipole 2.1-2.5GHz
*Antenna Gain: 2.15dBi

Antenna Chain2 Model: Omni Ant 2040, ½ wave dipole 2.2-2.5GHz
*Antenna Gain: 2.0dBi

Dates of testing: WLAN 2.4GHz, 25 September 2024 – 27 September 2024

**Data was not measured by SGS laboratory and therefore not responsible for accuracy. Data obtained via customer, specification sheet, previous regulatory filing or other.*

2.4 TX FREQUENCY BANDS

Band / Mode		Frequency Range MHz	Channel Bandwidths MHz	Specified Maximum Power (dBm)
WLAN 2.4GHz	802.11 b/g/n	2450 – 2483.5	20	28.6
			10	28.6
			5	28.6

2.5 EQUIPMENT UNDER TEST

Device Description	MPU5 with RF-2150 Radio Module
Device Category	Portable
Stage of production	Production unit
Intended Use	Body
Antennas	Chains 1 & 3 Ant-2005 Chain 2 Ant-2040
Battery	BT-70716BV-PS
Optional Accessories	NA

2.6 EUT PHOTO



Additional photos in Appendix A.

2.7 TEST METHODOLOGY AND REFERENCED STANDARDS AND GUIDELINES

Tests were conducted in accordance with the following applicable standards and guidelines.

IEC62209-1528 Edition 1.0 2020-10, Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices –

Part 1528: Human models, instrumentation, and procedures
 (Frequency Range of 4 MHz to 10 GHz)

Federal Communications Commission, “Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields”, OET Bulletin 65, FCC, Washington, D.C.: 1997.

FCC KDB – 447498 D01 General RF Exposure Guidance v06

FCC KDB – 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04

FCC KDB – 248227 D01 802.11 WiFi SAR v02r02

3 TEST EQUIPMENT AND MEASUREMENT SYSTEM

3.1 TEST EQUIPMENT

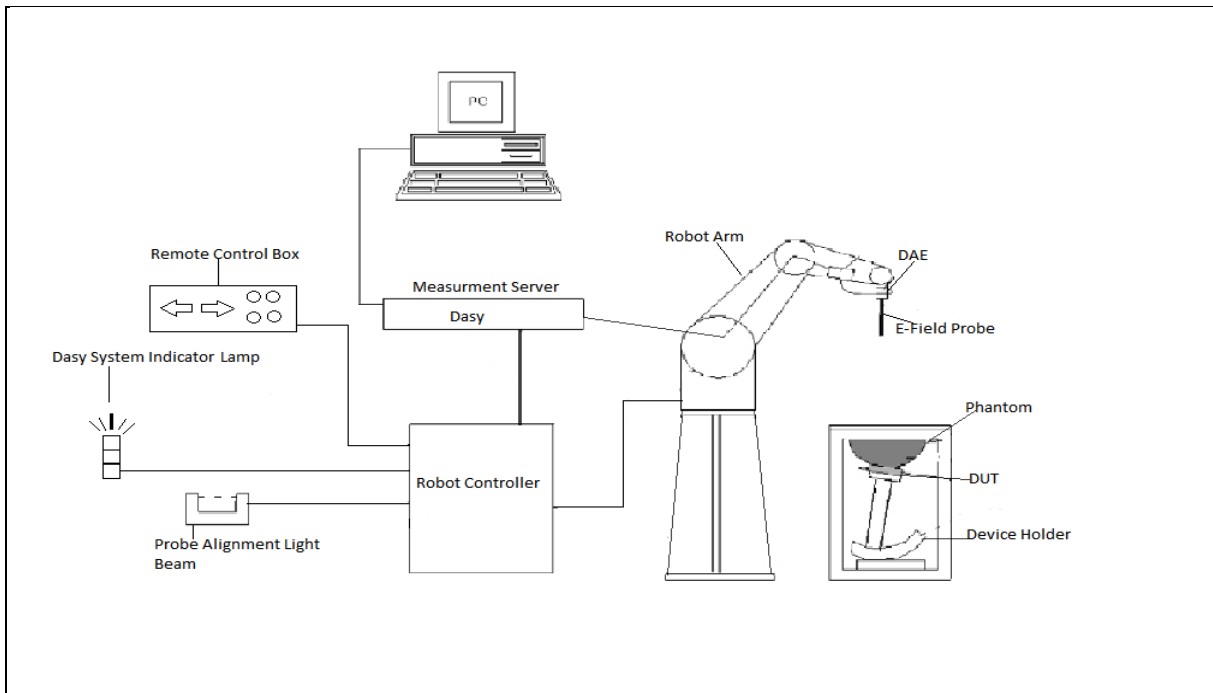
Test Start Date: 25-Sep-2024

Test End Date: 27-Sep-2024

Tester: PL

Equipment	Model	Manufacturer	Asset	Cal Date	Cal Due Date
POWER METER	E4419B	AGILENT	B079628	14-Nov-2023	14-Nov-2024
POWER SENSOR	8481A	AGILENT	B086132	17-Nov-2023	17-Nov-2024
ATTENUATOR, 10DB	BW-N10W20+	MINI-CIRCUITS	17023	7-Aug-2024	7-Aug-2025
SIGNAL GENERATOR (TS8997)	SMB 100A	ROHDE & SCHWARZ	B094876	16-Nov-2023	16-Nov-2026
N to N RF Cable	90-076-020	TELEDYNE STORM MICROWAVE	22036	26-Dec-2023	26-Dec-2024
N to N RF Cable	90-076-020	TELEDYNE STORM MICROWAVE	22035	26-Dec-2023	26-Dec-2024
RF CABLE	CBL-25FT- NMNM	MINI-CIRCUITS	B094941	7-Aug-2024	7-Aug-2025
85MHZ-14GHZ VECTOR REFLECTOMETER	R140	COPPER MOUNTAIN	20149	3-Apr-2024	3-Apr-2025
RF CABLE RIGHT ANGLE NM TO NM, 0.01-18GHZ	90-076-020	TELEDYNE STORM MICROWAVE	20132	20-Mar-2024	20-Mar-2025
ATTENUATOR, 20DB 100W	BW- 20N100W+	MINI-CIRCUITS	20143	20-Mar-2024	20-Mar-2025
DIRECTIONAL COUPLER	11692D	HEWLETT PACKARD	B079666	4-Aug-2023	4-Aug-2026
POWER SENSOR	8481A	AGILENT	B079679	17-Nov-2023	17-Nov-2024
DATA ACQUISITION ELECTRONICS	SD 000 D04 BM	SPEAG	16004	19-Feb-2024	19-Feb-2025
SAR DIPOLE	D2450V2	SPEAG	B079805	6-Feb-2024	6-Feb-2025
SAR DOSIMETRIC E-FIELD PROBE	ES3DV3	SPEAG	B079815	26-Feb-2024	26-Feb-2025
USB WIDEBAND POWER SENSOR	U2021XA	TSTPASS (KEYSIGHT TECHNOLOGIES)	20168C	15-Aug-2024	15-Aug-2025

3.3 MEASUREMENT SYSTEM BLOCK DIAGRAM



The DASY52 SAR test system version 52.10 (4) consists of:

- 1 TX60L Stäubli Robot and system controller cabinet
- 1 Electro Optical Converter mounted on robot's arm
- Robot stand
- Robot remote controller
- Light beam for E-field probe alignment
- DASY5 measurement server
- SAM Twin Phantom or Oval
- Hand-Held/ Laptop device holder
- PC with DASY5 software
- Data Acquisition Electronics (DAE)
- System validation dipole kit
- HBBL600-10000V6 Head Simulating Liquid
- E-field probe
- Warning lamps

3.4 MEASUREMENT SYSTEM PHANTOM DESCRIPTIONS

Type	Dimensions	Frequency Range	Dielectric (ϵ_r)	Loss Tangent	Material Thickness
Oval ELI5	600x400x190	300MHz - 6GHz	4 ± 1	<0.05	2mm $\pm$ 0.2mm
SAM	Human Shaped		< 5		

3.5 MEASUREMENT SYSTEM TISSUE DESCRIPTION

Broadband tissue simulation liquid HBBL600-10000V6 was used for SAR testing. Manufactured by Speag and main ingredients are water and oil.

Dielectric Assessment Kit (DAK) was used to measure tissue parameters daily.

4 SYSTEM VALIDATIONS AND VERIFICATIONS

4.1 SYSTEM VALIDATIONS – WLAN 2.4 GHz

System validations were completed following KDB 856664 and are summarized in table below.

Dates	Probe Calibration Point		Probe SN	Measured Tissue		Validation		
				σ	ϵ_r	Sensitivity	Linearity	Isotropy
CW								
3/13/2024	Head	2450	3272	37.763	1.806	Pass	Pass	Pass
802.11								
3/13/2024	Head	2450	3272	37.763	1.806	Pass	Pass	Pass

4.2 SYSTEM VERIFICATIONS

System verification is required for the probe calibration points used to measure SAR. The measured results are normalized to 1W and compared to the results from applicable dipole calibration certificates. Results must be within $\pm 10\%$ of target values.

System verifications were completed within 24 hours of SAR testing and results are summarized in table below.

Date	Dipole	Probe Calibration Point	Zoom SAR (1g)	Zoom SAR Normalized (1W)	1W Dipole Target SAR (1g)	% Error from Validation Target
9/25/2024	D2450V2	2450	4.00	53.33	51.4	3.76%
9/26/2024	D2450V2	2450	4.04	53.87	51.4	4.80%
9/27/2024	D2450V2	2450	4.16	55.47	51.4	7.91%

4.3 TISSUE MEASUREMENT RESULTS

The tissue dielectric parameters were measured at the beginning of the test or within 24 hours of the first SAR test. All measured dielectric parameters are within $\pm 10\%$ tolerance values shown in Table 1. The $\pm 10\%$ tolerance is permitted when using SAR correction formula for deviation from target dielectric values.

Date	Frequency MHz	Measured		Target		Deviation	
		Permittivity	Conductivity	Permittivity	Conductivity	Permittivity	Conductivity
		ϵ_r	σ	ϵ_r	σ	ϵ_r	σ
WLAN 2.4 GHz							
9/25/2024	2450	36.45	1.74	39.20	1.80	-7.02	-3.43
	2462	36.43	1.75	39.18	1.81	-7.02	-3.69
	2467	36.43	1.75	39.18	1.82	-7.02	-3.79
	2472	36.42	1.75	39.17	1.82	-7.03	-3.90
9/26/2024	2450	37.23	1.75	39.20	1.80	-5.02	-2.63
	2462	37.22	1.76	39.18	1.81	-5.02	-2.89
	2467	37.21	1.76	39.18	1.82	-5.02	-2.99
	2472	37.20	1.77	39.17	1.82	-5.03	-3.09
9/27/2024	2450	37.25	1.75	39.20	1.80	-4.99	-2.81
	2462	37.25	1.75	39.17	1.82	-4.99	-2.81
	2467	37.22	1.76	39.22	1.79	-5.00	-3.13

5 ENVIRONMENTAL CONDITIONS

The SAR Laboratory is controlled environment. The ambient temperature is maintained between 18 – 25°C and tissue temperatures are monitored to ensure $\pm 2^\circ\text{C}$ is maintained otherwise tissue parameters are remeasured. The tissue level is confirmed to be $\geq 15\text{cm}$.

Date	Tissue Type	Tissue Temp. Range C°	Lab Temp. Range C°
9/25/2024	Head	22.62 – 24.23	24.38 – 24.86
9/26/2024	Head	23.01 – 23.98	24.48 – 24.80
9/27/2024	Head	22.18 – 22.31	22.82 – 23.46

RF ambient noise is monitored by conducting a noise cube scan during system verification. A spectrum analyzer is used to monitor unwanted signals that might influence measurements.

The tissue depth was verified to be $\geq 15\text{cm}$.

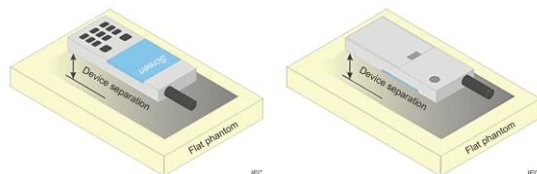
6 MEASUREMENT PROCEDURES

6.1 HEAD CONFIGURATION

NA

6.2 BODY-WORN CONFIGURATION

A Body-worn device is a battery-operated wireless device with the ability to transmit while in close proximity to the user's body. This device shall be positioned 50mm from user's body. Photos of EUT are included in Part 2 of this report.



6.3 LIMB CONFIGURATION

NA

6.4 SAR PROCEDURES SETUP

- Area Scan is used for a fast scan in two dimensions to find the area of high field values before any finer measurement around the hotspot. The routines implemented in the DASY5 software can find the maximum locations.
- Zoom Scan is used to assess the peak spatial values within a cubic averaging volume containing 1g and 10g of simulated tissue. The scan measures points within the cube. Once measurement is done the values are displayed within the job's label.
- Power Drift will measure the field at the same location as the most recent power reference measurement within the same procedure and settings. The Power Drift Measurement gives the field difference in dB.
- Z- Scan measure points along a straight vertical line. The lines run along the z-axis of a one-dimension grid.

The area and zoom scan resolutions specified in KDB 865664 are in table below.

Description		≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface		5 mm ± 1 mm	$\frac{1}{2} \delta \cdot \ln(2)$ mm ± 0.5 mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location		30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: Δx_{Area} , Δy_{Area}		≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
		When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	
Maximum zoom scan spatial resolution: Δx_{Zoom} , Δy_{Zoom}		≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$	≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see IEEE Std 1528-2013 for details. * When zoom scan is required and the reported SAR from the area scan based 1-g SAR estimation procedures of KDB Publication 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.			

7 MEASURED OUTPUT POWER MEASUREMENTS

Mode	Bandwidth	Channel	Freq (MHz)	lowest data rate	Antenna	Power (dBm)
802.111b	20MHz	11	2462	1 Mbps	Chain 1	28.21
		12	2467			28.15
		13	2472			28.47
		11	2462		Chain 2	28.23
		12	2467			28.27
		13	2472			28.22
		11	2462		Chain 3	27.36
		12	2467			27.75
		13	2472			27.6

Additional channels did not required SAR measurements per SAR test reduction procedure.

8 SAR RESULTS

Scaled SAR results include scaling up to maximum tune-up tolerance and negative drift.

WLAN SAR Test Reduction Procedure:

KDB 248227 D01 802.11 WiFi SAR:

KDB Section 5.1.1 Initial Test Position SAR Test Reduction Procedure

a) When the reported SAR of the initial test position is ≤ 0.4 W/kg, further SAR measurement is not required for the other (remaining) test positions in that exposure configuration and 802.11 transmission mode combinations within the frequency band or aggregated band. SAR is also not required for that exposure configuration in the subsequent test configuration(s).

b) When the reported SAR of the initial test position is > 0.4 W/kg, SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position using subsequent highest extrapolated or estimated 1-g SAR conditions determined by area scans or next closest/smallest test separation distance and maximum RF coupling test positions based on manufacturer justification, on the highest maximum output power channel, until the reported SAR is ≤ 0.8 W/kg or all required test positions (left, right, touch, tilt or subsequent surfaces and edges) are tested.

c) For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required channels are tested

Section 5.2.1 802.11b DSSS SAR Test Requirements SAR is measured for 2.4 GHz 802.11b DSSS using either a fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:

a) When the reported SAR of the highest measured maximum output power channel (see 3.1) for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.

b) When the reported SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

5.3.2 OFDM Transmission Mode SAR Test Configuration and Channel Selection Requirements The initial test configuration for 2.4 GHz and 5 GHz OFDM transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures (see Clause 4)

8.1 WLAN 2.4GHz

Antenna	Test Mode	Channel	Frequency (MHz)	Test Position 50mm	Duty Cycle (%)	Max Power (dBm)	Meas. Power (dBm)	Power Scaling factor	Drift (dB)	Drift Scaling factor	Meas. SAR 1g	Meas. SAR 10g	Scaled SAR 1g	Scaled SAR 10g	Plot No.
Chain 1	802.11b 1 Mbps	13	2472	Back	99	28.6	28.47	1.03	-0.21	1.050	0.483	0.296	0.522	0.320	1
		11	2462	Back	99	28.6	28.41	1.09	0.01	1.000	0.450	0.276	0.492	0.302	
		13	2472	Front	99	28.6	28.47	1.03	0.29	1.000	0.272	0.166	0.280	0.171	2
Chain 2	802.11b 1 Mbps	11	2467	Back	99	28.6	28.27	1.08	-0.2	1.047	0.397	0.244	0.449	0.276	
		12	2462	Back	99	28.6	28.23	1.09	-0.05	1.012	0.495	0.305	0.545	0.336	3
		13	2467	Front	99	28.6	28.23	1.41	-0.12	1.028	0.166	0.103	0.184	0.114	4
Chain 3	802.11b 1 Mbps	11	2467	Back	99	28.6	27.75	1.22	0.01	1.000	0.390	0.237	0.474	0.288	5
		12	2472	Back	99	28.6	27.6	1.26	0.28	1.000	0.362	0.219	0.456	0.276	
		13	2467	Front	99	28.6	27.75	1.22	-0.13	1.030	0.243	0.149	0.305	0.187	6

9 VARIABILITY ASSESSMENT

Per the guidelines in KDB 865664 SAR variability assessment is not required because SAR results are below 50% threshold of applicable limit.

10 SIMULTANEOUS TRANSMISSION

This device does support simultaneous transmissions between chains 1 and 2 and 1, 2 & 3.

10.1 DIRECT SUMMATION

Position	Simultaneous TX Antenna Combination			SAR	SAR	SAR	Total SAR	Limit
	Chain 1	Chain 2	Chain 3	Chain 1	Chain 2	Chain 3	mW/g	mW/g
Back	2472 MHz	2462 MHz	2467 MHz	0.522	0.545	0.474	1.54	1.6
	2472 MHz	2462 MHz	N/A	0.522	0.545	N/A	1.07	1.6
Front	2472 MHz	2462 MHz	2467 MHz	0.28	0.184	0.305	0.77	1.6
	2472 MHz	2462 MHz	N/A	0.28	0.184	N/A	0.46	1.6

11 SYSTEM UNCERTAINTY

A System uncertainty analysis per KDB 865664 is not required since reported SAR is < 93.75% of applicable limit.

Per guidelines of ISO 17025 reported system uncertainty is required and therefore included in Part 3.

12 REVISION HISTORY

Revision Level	Description of changes	Revision Date
0	Initial release	21 October 2024