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KCF Technologies, Inc.
MPE REPORT

SCOPE OF WORK
MPE CALCULATION
ON THE SD-BASE-4

REPORT NUMBER
104699147LEX-023.1

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9/3/2021 1/5/2023

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DOCUMENT CONTROL NUMBER
Non-Specific EMC Report Shell Rev. December 2017

MPE TEST REPORT

Report Number: 104699147LEX-023.1
Project Number: G104699147

Report Issue Date: 9/3/2021
Report Revised Date: 1/5/2023

Product Name: SD-BASE-4

Standards: FCC Part 1.1310 Limits for Maximum Permissible Exposure (MPE)

RSS-102 Issue 5 RF Field Strength Limits for Devices Used by the General Public

IEC62311: 2019

Tested by:
Intertek Testing Services NA, Inc.
731 Enterprise Drive
Lexington, KY 40510
USA

Client:
KCF Technologies, Inc.
336 S Fraser St
State College, PA 16801-4830
USA

Report prepared by

Brian Lackey, Team Leader

Report reviewed by

James Sudduth, Senior Staff Engineer

Table of Contents

1 Introduction and Conclusion

The tests indicated in section 2.0 were performed on the product constructed as described in section 4.0. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test Method, a list of the actual Test Equipment Used, documentation Photos, Results and raw Data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested **complies** with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

2 Test Summary

Section	Test full name	Result
11	FCC Part 1.1310 Limits for Maximum Permissible Exposure (MPE) (Limits for General Population / Uncontrolled Exposure)	Pass
	RSS-102 Issue 5 RF Field Strength Limits (For Devices Used by the General Public)	Pass
	IEC62311: 2019 MPE Limits (For General Public Exposure)	Pass

3 Client Information

This product was tested at the request of the following:

Client Information	
Client Name:	KCF Technologies, Inc.
Address:	336 S Fraser St State College, PA 16801-4830 USA
Contact:	Edward Adams
Telephone:	+1 (814) 867-4097
Email:	eadams@kcftech.com
Manufacturer Information	
Manufacturer Name:	KCF Technologies, Inc.
Manufacturer Address:	336 S Fraser St State College, PA 16801-4830 USA

4 Description of Equipment under Test and Variant Models

Equipment Under Test	
Product Name	SD-BASE-4
Model Number	SD-BASE-4
Supported Transmit Bands	LTE Bands: 2, 4, 5, 7, 12, 13, 26, 41, 66 (US); 1, 3, 7, 8, 20, 28, 42 (EU) Wi-Fi: 2.4GHz, 5GHz U-NII-1, U-NII-3 Bluetooth: 2.4GHz PRN: 2.4GHz
Embedded Modules	Sierra Wireless EM7565 (FCCID: N7NEM75) Wi-Fi + Bluetooth: SparkLAN WPEQ-262ACNI (FCCID: RYK-WPEQ262ACNIBT) PRN: U-blox BMD-345 (FCCID: XPYBMD345)
Antenna Information:	Cell: W5067, 700/1710/2400MHz, 2dBi gain Wi-Fi + Bluetooth: W5030, 2.4-2.5GHz / 5.15-5875GHz, 4/6dBi gain
Receive Date	4/29/2021
Test Start Date	9/3/2021
Test End Date	9/3/2021
Device Received Condition	Good
Test Sample Type	Production
Rated Voltage	120VAC

Description of Equipment Under Test (provided by client)
The SD-BASE-4 is an IoT Gateway device. It serves as a gateway for wireless industrial sensors, collecting, buffering and forwarding the sensor data to the cloud.

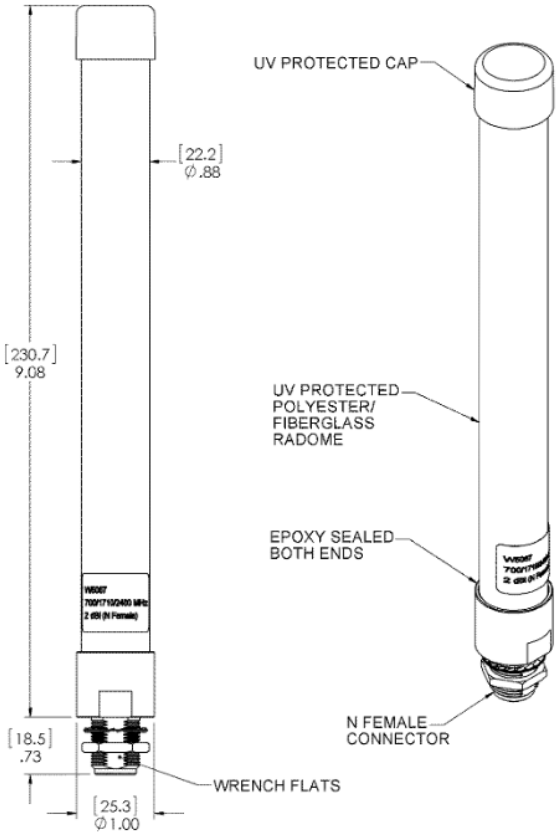
4.1 Variant Models:

There were no variant models covered by this evaluation.

5 Antenna Gains:

The information in this section was provided by the client and may affect compliance. Intertek does not make any claims of compliance for values other than those shown below.

The cellular antenna was a Pulse Larsen P/N W5067. The drawing and electrical specifications are shown below.



ELECTRICAL SPECIFICATIONS		
Antenna type	Dipole (All electrical performance measured "in free space")	
Frequency	698-960/1710-2170/2400-2700	MHz
Nominal Impedance	50	Ω
VSWR	2:1	Max
Average Peak Gain 700	0.7	dBi
Average Peak Gain 1710	1.0	dBi
Average Peak Gain 2400	2.0	dBi
Efficiency	61	% Avg
HPBW / Horizontal Plane	Omni	
HPBW / Vertical Plane 700	56	° TYP
HPBW / Vertical Plane 1710	36	° TYP
HPBW / Vertical Plane 2400	24	° TYP
Polarization:	Vertical	
Power withstanding	3	W
Connector type	N-Female	

The Wi-Fi and Bluetooth antenna was a Pulse Larsen P/N W5030. The drawing and electrical specifications are shown below.

ELECTRICAL SPECIFICATIONS	
Frequency 1 (GHz)	2.4 - 2.5
Frequency 2 (GHz)	5.15 – 5.875
Nominal Impedance (Ω)	50
VSWR (Max)	2:1
Average Peak Gain 2.4 GHz (dBi)	3.5
Average Peak Gain 5X GHz (dBi)	6.5
HPWB / Horizontal Plane	Omni
HPBW / Vertical Plane 2.4 GHz (° TYP)	45
HPBW / Vertical Plane 5X GHz (° TYP)	25
Polarization	Vertical
Power Withstanding (W)	20
E.S.D. Protection	External Recommended
Connector Type	N Male

6 Output Power:

The information in this section was provided by the client and may affect compliance. Intertek does not make any claims of compliance for values other than those shown below.

The maximum output power of the cellular module was taken from the module's grant, FCCID N7NEM75:

Line Entry	Lower Frequency	Upper Frequency	Power Output	Tolerance	Emission Designator	Microprocessor Number	Rule Parts	Grant Notes
1	824	849	0.193	2.5 ppm	4M12F9W		22H	BC
2	1850	1910	0.181	2.5 ppm	4M14F9W		24E	BC
3	1710	1755	0.192	2.5 ppm	4M12F9W		27	BC
4	1850	1910	0.18	2.5 ppm	18M5G7D		24E	BC
5	1850	1910	0.155	2.5 ppm	18M5W7D		24E	BC
6	2500	2570	0.152	2.5 ppm	18M5G7D		27	BC
7	2500	2570	0.129	2.5 ppm	18M5W7D		27	BC
8	2500	2570	0.157	2.5 ppm	4M50G7D		27	BC
9	2500	2570	0.134	2.5 ppm	4M50W7D		27	BC
1	699	716	0.189	2.5 ppm	9M11G7D		27	BC
11	699	716	0.16	2.5 ppm	9M09W7D		27	BC
12	699	716	0.161	2.5 ppm	2M73W7D		27	BC
13	777	787	0.193	2.5 ppm	8M97G7D		27	BC
14	777	787	0.165	2.5 ppm	9M01W7D		27	BC
15	824	849	0.192	2.5 ppm	13M5G7D		22H	BC
16	824	849	0.16	2.5 ppm	13M5W7D		22H	BC
17	814	824	0.19	2.5 ppm	14M2G7D		9	BC
18	814	824	0.157	2.5 ppm	14M5W7D		9	BC
19	814	824	0.16	2.5 ppm	3M03W7D		9	BC
2	2496	2690	0.158	2.5 ppm	18M5G7D		27	BC
21	2496	2690	0.129	2.5 ppm	18M5W7D		27	BC
22	2496	2690	0.13	2.5 ppm	14M5W7D		27	BC
23	1710	1780	0.199	2.5 ppm	18M3G7D		27	BC
24	1710	1780	0.169	2.5 ppm	18M5W7D		27	BC
25	2305	2315	0.138	2.5 ppm	8M99G7D		27	BC
26	2305	2315	0.116	2.5 ppm	9M05W7D		27	BC
27	2305	2315	0.139	2.5 ppm	4M51G7D		27	BC
28	2305	2315	0.117	2.5 ppm	4M49W7D		27	BC
29	2500	2570	0.199	2.5 ppm	37M5G7D		27	BC
3	2500	2570	0.166	2.5 ppm	37M7W7D		27	BC
31	2496	2690	0.199	2.5 ppm	37M7G7D		27	BC
32	2496	2690	0.181	2.5 ppm	37M9W7D		27	BC

The maximum output power of the Bluetooth and Wi-Fi module was taken from the module's grant, FCCID RYK-WPEQ262ACNIBT:

Line Entry	Lower Frequency	Upper Frequency	Power Output	Tolerance	Emission Designator	Microprocessor Number	Rule Parts	Grant Notes
1	2402	2480	0.002				15C	CC
2	2412	2462	0.128				15C	CC,MO

Line Entry	Lower Frequency	Upper Frequency	Power Output	Tolerance	Emission Designator	Microprocessor Number	Rule Parts	Grant Notes
1	2402.00000000	2480.00000000	0.0130000				15C	CC

Line Entry	Lower Frequency	Upper Frequency	Power Output	Tolerance	Emission Designator	Microprocessor Number	Rule Parts	Grant Notes
1	5180	5240	0.159				15E	CC,MO
2	5260	5320	0.154				15E	CC,MO,ND
3	5500	5720	0.16				15E	CC,MO,ND
4	5745	5825	0.195				15E	CC,MO

The maximum output power of the PRN module was taken from the module's grant, FCCID XPYBMD345:

Line Entry	Lower Frequency	Upper Frequency	Power Output	Tolerance	Emission Designator	Microprocessor Number	Rule Parts	Grant Notes
1	2402	2480	0.0645				15C	
2	2405	2480	0.0624				15C	

6.1 EUT Photo (Front):

6.2 EUT Photo (Back):

7 FCC Limits

§ 1.1310: The criteria listed in table 1 shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

Part 1.1310 Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
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
300–1500	.....	.....	f/300	6
1500–100,000	.....	.....	5	6
(B) 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
300–1500	.....	.....	f/1500	30
1500–100,000	.....	.....	1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

8 RSS-102 Issue 5 Exposure Limits:

Table 4: RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Reference Period (minutes)
0.003-10[21]	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	-2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
* Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

9 IEC62311 (ICNIRP) Exposure Limits:

Table 7. Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
up to 1 Hz	—	3.2×10^4	4×10^4	—
1–8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8–25 Hz	10,000	$4{,}000/f$	$5{,}000/f$	—
0.025–0.8 kHz	$250/f$	$4/f$	$5/f$	—
0.8–3 kHz	$250/f$	5	6.25	—
3–150 kHz	87	5	6.25	—
0.15–1 MHz	87	$0.73/f$	$0.92/f$	—
1–10 MHz	$87/f^{1/2}$	$0.73/f$	$0.92/f$	—
10–400 MHz	28	0.073	0.092	2
400–2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	$f/200$
2–300 GHz	61	0.16	0.20	10

[a] Note:
1. f as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. perception of surface electric charges will not occur at field strengths less than 25 kVm^{-1}. Spark discharges causing stress or annoyance should be avoided.

10 Test Procedure

An MPE evaluation for was performed in order to show that the device was compliant with the general population exposure limits from FCC §2.1091 and RSS-102 Issue 5. The maximum power density was calculated for each transmitter band at a separation distance of 20cm using the maximum declared output power including tune up tolerance.

For each transmitter the maximum RF exposure at a 20 cm distance using the formula:

$$ConductedPower_{mW} = 10^{ConductedPower(dBm)/10}$$

$$PowerDensity = \frac{ConductedPower_{mW} \times Ant.Gain}{4\pi \times (20_{cm})^2}$$

For transmitters that could operate simultaneously, the MPE to limit ratio for each was calculated and then summed. If the sum of the MPE to limit ratios was less than 1, that specific combination of transmitters was deemed to comply.

11 Results:

The calculated maximum power density at 20cm distance was equal to or less than the required limits for general population exposure for FCC Part 1.1310, RSS-102 Issue 5, and IEC62311: 2019.

11.1 FCC MPE Data

Duty Cycle	100 (%)							
Separation Dist.	20 (cm)							
Operating Mode	Frequency (MHz)	Declared Max Cond. Power (Inc. Tolerance) (dBm)	Duty Cycle Adjusted Cond. Output Power (dBm)	Antenna Gain (dB)	MPE Value (mW/cm^2)	MPE Limit (mW/cm^2)	Margin to Limit (mW/cm^2)	MPE / Limit Ratio (for Co-Location)
LTE B2	1850	24	24.00	1.0	0.0629	1.0000	0.9371	0.0629
LTE B4	1710	24	24.00	1.0	0.0629	1.0000	0.9371	0.0629
LTE B5	824	24	24.00	0.7	0.0587	0.5493	0.4906	0.1069
LTE B7	2500	23.8	23.80	2.0	0.0756	1.0000	0.9244	0.0756
LTE B12	699	24	24.00	0.7	0.0587	0.4660	0.4073	0.1260
LTE B13	777	24	24.00	0.7	0.0587	0.5180	0.4593	0.1133
LTE B26	814	24	24.00	0.7	0.0587	0.5427	0.4840	0.1082
LTE B30	2305	23	23.00	2.0	0.0629	1.0000	0.9371	0.0629
LTE B41	2496	23.8	23.80	2.0	0.0756	1.0000	0.9244	0.0756
LTE B66	1710	24	24.00	1.0	0.0629	1.0000	0.9371	0.0629
Bluetooth	2402	11.1	11.10	3.5	0.0057	1.0000	0.9943	0.0057
2.4GHz Wi-Fi	2412	21.08	21.08	3.5	0.0571	1.0000	0.9429	0.0571
5GHz Wi-Fi, U-NII-1	5180	22.00	22.00	6.5	0.1408	1.0000	0.8592	0.1408
5GHz Wi-Fi, U-NII-3	5745	22.91	22.91	6.5	0.1737	1.0000	0.8263	0.1737
PRN	2405	17.98	17.98	3.5	0.0280	1.0000	0.9720	0.0280

The worst case simultaneous transmission is with LTE B12, Bluetooth, 5GHz U-NII-3, and PRN radios transmitting. The simultaneous MPE to limit ratio is:

0.1260 + 0.0057 + 0.1737 + 0.0280 = 0.3334

Since the combined MPE to limit ratio is less than 1, the device is deemed to comply with simultaneous transmission requirements.

11.2 RSS-102 Issue 5 MPE Data

Duty Cycle	100 (%)							
Separation Dist.	20 (cm)							
Operating Mode	Frequency (MHz)	Declared Max Cond. Power (Inc. Tolerance) (dBm)	Duty Cycle Adjusted Cond. Output Power (dBm)	Antenna Gain (dB)	MPE Value (W/m^2)	MPE Limit (W/m^2)	Margin to Limit (W/m^2)	MPE / Limit Ratio (for Co-Location)
LTE B2	1850	24	24.00	1.0	0.6291	4.4763	3.8472	0.1405
LTE B4	1710	24	24.00	1.0	0.6291	4.2419	3.6128	0.1483
LTE B5	824	24	24.00	0.7	0.5871	2.5756	1.9885	0.2280
LTE B7	2500	23.8	23.80	2.0	0.7564	5.4991	4.7427	0.1375
LTE B12	699	24	24.00	0.7	0.5871	2.3017	1.7146	0.2551
LTE B13	777	24	24.00	0.7	0.5871	2.4743	1.8872	0.2373
LTE B26	814	24	24.00	0.7	0.5871	2.5542	1.9671	0.2299
LTE B30	2305	23	23.00	2.0	0.6291	5.2022	4.5731	0.1209
LTE B41	2496	23.8	23.80	2.0	0.7564	5.4930	4.7367	0.1377
LTE B66	1710	24	24.00	1.0	0.6291	4.2419	3.6128	0.1483
Bluetooth	2402	11.1	11.10	3.5	0.0574	5.3508	5.2934	0.0107
2.4GHz Wi-Fi	2412	21.08	21.08	3.5	0.5711	5.3660	4.7949	0.1064
5GHz Wi-Fi, U-NII-1	5180	22.00	22.00	6.5	1.4084	9.0471	7.6387	0.1557
5GHz Wi-Fi, U-NII-3	5745	22.91	22.91	6.5	1.7367	9.7103	7.9736	0.1789
PRN	2405	17.98	17.98	3.5	0.2797	5.3554	5.0756	0.0522

The worst case simultaneous transmission is with LTE B12, Bluetooth, 5GHz U-NII-3, and PRN radios transmitting. The simultaneous MPE to limit ratio is:

0.2551 + 0.0107 + 0.1789 + 0.0522 = 0.4969

Since the combined MPE to limit ratio is less than 1, the device is deemed to comply with simultaneous transmission requirements.

11.3 IEC 62311 MPE Data

Duty Cycle	100 (%)							
Separation Dist.	20 (cm)							
Operating Mode	Frequency (MHz)	Declared Max Cond. Power (Inc. Tolerance) (dBm)	Duty Cycle Adjusted Cond. Output Power (dBm)	Antenna Gain (dB)	MPE Value (W/m^2)	MPE Limit (W/m^2)	Margin to Limit (W/m^2)	MPE / Limit Ratio (for Co-Location)
LTE B1	1920	24	24.00	1.0	0.6291	9.6000	8.9709	0.0655
LTE B3	1710	24	24.00	1.0	0.6291	8.5500	7.9209	0.0736
LTE B7	2500	23	23.00	2.0	0.6291	10.0000	9.3709	0.0629
LTE B8	880	24	24.00	0.7	0.5871	4.4000	3.8129	0.1334
LTE B20	832	24	24.00	0.7	0.5871	4.1600	3.5729	0.1411
LTE B28	703	24	24.00	0.7	0.5871	3.5150	2.9279	0.1670
LTE B42	3400	23	23.00	2.0	0.6291	10.0000	9.3709	0.0629
Bluetooth	2402	11.1	11.10	3.5	0.0574	10.0000	9.9426	0.0057
2.4GHz Wi-Fi	2412	21.08	21.08	3.5	0.5711	10.0000	9.4289	0.0571
5GHz Wi-Fi, U-NII-3	5745	22.91	22.91	6.5	1.7367	10.0000	8.2633	0.1737
PRN	2405	17.98	17.98	3.5	0.2797	10.0000	9.7203	0.0280

The worst case simultaneous transmission is with LTE B28, Bluetooth, 5GHz U-NII-3, and PRN radios transmitting. The simultaneous MPE to limit ratio is:

0.1670 + 0.0057 + 0.1737 + 0.0280 = 0.3744

Since the combined MPE to limit ratio is less than 1, the device is deemed to comply with simultaneous transmission requirements.

12 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	9/3/2021	104699147LEX-023	BL	BCT	Original Issue
1	1/5/2023	104699147LEX-023.1	BL	JTS	Added Bluetooth