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Subject: RF exposure analysis for the equipment with FCC ID: **RI7HE9223GR**; IC: **5131A-HE9223GR**

The device model: **HE922-3GR** (FCC ID: **RI7HE9223GR**; IC: **5131A-HE9223GR**) is designed to be installed in and used in mobile exposure conditions.

The antennas used for this device must be installed to provide a separation distance of at least 20 cm from all the persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

MPE exposure limits

The table below is excerpted from Table 1B of 47 CFR 1.1310 titled Limits for Maximum Permissible Exposure (MPE), Limits for General Population/Uncontrolled Exposure:

Frequency Range (MHz)	Power density (mW/cm^2)	Averaging time (minutes)
300 – 1500	f (MHz) /1500	30
1500 – 100.000	1,0	30

The table below is excerpted from RSS-102, Issue 5, section 4, titled “RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)”:

Frequency Range (MHz)	Power density (W/m^2)	Reference Period (minutes)
300 – 6000	$0.02619 f^{0.6834}$	6
6000 - 15000	10	6
15000 - 150000	10	$616000/ f^{1.2}$

Compliance analysis

Using the equation $S = \frac{PG}{4\pi R^2}$ to calculate the exposure to electromagnetic fields

where: S = power density (in appropriate units, e.g. mW/cm^2)
P = power input to the antenna (in appropriate units, e.g., mW)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

compliance with FCC and IC MPE and EIRP limits is demonstrated based on the following calculations:

1. Standalone analysis

1.1 RF exposure in 2.4 GHz band:

Calculations done using the antenna gain specified for this band.

Frequency Band	Mode	Frequency Range (MHz)	Reference frequency (Lowest freq.) (MHz)	Maximum conducted output power Pin (dBm)	TX slots	Duty cicle (%)	Evaluation distance R (cm)	Antenna gain (dBi)	S (mW/cm^2)	MPE limit in USA (mW/cm2)	MPE limit in Canada (mW/cm2)	Worst case MPE limit	MPE Ratio (S/MPE limit)
2,4 ISM	**BLE**	2402 - 2480	2402,0	5,49	N/A	100,0%	20	2,30	0,0012	1,0000	0,5351	0,5351	0,0022
2,4 ISM	**BL + EDR (GFSK)**	2402 - 2480	2402,0	6,27	N/A	100,0%	20	2,30	0,0014	1,0000	0,5351	0,5351	0,0027
2,4 ISM	**BL + EDR (pi/4-DQPSK)**	2402 - 2480	2402,0	6,90	N/A	100,0%	20	2,30	0,0017	1,0000	0,5351	0,5351	0,0031
2,4 ISM	**BL + EDR (8-DPSK)**	2402 - 2480	2402,0	6,82	N/A	100,0%	20	2,30	0,0016	1,0000	0,5351	0,5351	0,0030
2,4 ISM	**WiFi 2.4 GHz (802.11b)**	2412 - 2462	2412,0	19,32	N/A	100,0%	20	2,30	0,0289	1,0000	0,5366	0,5366	0,0539
2,4 ISM	**WiFi 2.4 GHz (802.11g)**	2412 - 2462	2412,0	17,21	N/A	100,0%	20	2,30	0,0178	1,0000	0,5366	0,5366	0,0332
2,4 ISM	**WiFi 2.4 GHz (802.11n20))**	2412 - 2462	2412,0	16,42	N/A	100,0%	20	2,30	0,0148	1,0000	0,5366	0,5366	0,0276

1.2 Maximum antenna gains for GSM and UMTS interfaces. Calculations done to comply with MPE and EIRP limits

Now we calculate the maximum antenna gains so compliance with MPE and EIRP in both USA and Canada is fulfilled.

Frequency Band	Mode	Frequency Range (MHz)	Reference frequency (Lowest freq.) (MHz)	Maximum conducted output power (per tune-up) (dBm)	TX slots	Duty cicle (%)	Evaluation distance (cm)	MPE limit in USA (mW/cm^2)	MPE limit in Canada (mW/cm^2)	EIRP limit in USA per FCC §22,913, §24,232 (W)	EIRP limit in Canada per SRSP-503, SRSP-510 (W)	Antenna gain to meet FCC MPE limit G (dBi)	Antenna gain to meet FCC EIRP limit G (dBi)	Antenna gain to meet ISED MPE limit G (dBi)	Antenna gain to meet ISED EIRP limit G (dBi)	Maximum Antenna gain to comply MPE and EIRP in all bands in USA and Canada (dBi)
GSM 850	**GSM/GPRS (class 10)**	824,2 - 848,8	824,2	32,50	2	25,0%	20	0,5495	0,2576	11,4800	11,5000	7,93	8,09	4,64	8,10	4,64
UMTS B5	**WCDMA / HSUPA**	826,4 - 846,6	826,4	23,50	N/A	100,0 %	20	0,5509	0,2581	11,4800	11,5000	10,92	17,09	7,63	17,10	
PCS 1900	**GSM/GPRS (class 10)**	1850,2 - 1909,8	1850,2	30,90	2	25,0%	20	1,0000	0,4477	2,0000	2,0000	12,13	2,11	8,64	2,11	2,11
UMTS B2	**WCDMA / HSUPA**	1852,4 - 1907,6	1852,4	23,40	N/A	100,0 %	20	1,0000	0,4480	2,0000	2,0000	13,61	9,61	10,12	9,61	

2. Co-location analysis

2.1 Co-location with other transmitter in mobile exposure conditions

As specified in the operational description, cellular transmitter can work simultaneously with the transmitter in the 2.4GHz band so an analysis of the co-location with other transmitter in mobile exposure conditions is required.

Only one of these 2.4 GHz modes works at a given moment and it can work simultaneously with any of the cellular modes.

According to KDB 447498 D01 General RF Exposure Guidance v06, 7.2:

> *Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device, based on calculated or measured field strengths or power density, is ≤ 1.0.*

As the maximum calculated MPE ratio for the device is 0.0539 in the mode **WiFi 2.4 GHz (802.11n20)**, the product can be co-located with other antennas in the cellular mode providing that the sum of the MPE ratios for all the other simultaneous transmitting antennas incorporated in a host device, based on calculated or measured field strengths or power density is $\leq 1.0 - 0.0539 = 0.9461$

2.2 RF exposure for GSM and UMTS modes

The antenna gains calculated in 1.2 are in compliance with 2 criteria, MPE and EIRP limits for both countries, USA and Canada.

Nevertheless there is a third criterion that we need to meet. As the cellular interface can work simultaneously with the 2.4 GHz interface, the MPE ratio for each cellular mode must also be in compliance with the MPE Ratio for use in co-location defined in 2.1

The antenna gain of 2.11 dBi for the 1900 MHz band is not a problem.

If we would use an antenna gain of 4.64 dBi in the 850 MHz band, then the MPE Ratio for the **GSM/GPRS (class 10)** mode would be greater than 0.9461

Hence, to comply with this third criterion of MPE ratio to work in co-location below 0.9461, the antenna gain has to be reduced until 4.37 dBi

The table below shows the values of S and the MPE ratio under these conditions

Frequency Band	Mode	Frequency Range (MHz)	Reference frequency (Lowest freq.) (MHz)	Maximum conducted output power (per tune-up) Pin (dBm)	TX slots	Duty cicle (%)	Evaluation distance (cm)	Maximum Antenna gain to comply MPE and EIRP in all bands in USA and Canada (dBi)	S (mW/cm^2)	MPE limit in USA (mW/cm^2)	MPE limit in Canada (mW/cm^2)	Worst case MPE	MPE Ratio (S/MPE limit)
GSM 850	**GSM/GPRS (class 10)**	824,2 - 848,8	824,2	32,50	2	25,0%	20	4,37	0,2423	0,5495	0,2576	0,2576	0,9407
UMTS B5	**WCDMA / HSUPA**	826,4 - 846,6	826,4	23,50	N/A	100,0%	20	4,37	0,1220	0,5509	0,2581	0,2581	0,4729
PCS 1900	**GSM/GPRS (class 10)**	1850,2 - 1909,8	1850,2	30,90	2	25,0%	20	2,11	0,0995	1,0000	0,4477	0,4477	0,2222
UMTS B2	**WCDMA / HSUPA**	1852,4 - 1907,6	1852,4	23,40	N/A	100,0%	20	2,11	0,0708	1,0000	0,4480	0,4480	0,1579

3 Conclusion

To meet all the established criteria, the antenna gains in the cellular modes must be:

Frequency range	Antenna gain
850 MHz band	4.37 dBi
1900 MHz band	2.11 dBi
2.4 GHz band	2.3 dBi

Final MPE with Co-location.

The worst cases of working in co-location are below.
They are **WiFi 2.4 GHz (802.11b)** and **GSM/GPRS (class 10)**

The antenna gain used for the 850 MHz band is the optimum case to comply with the MPE and EIRP limits and additionally give an MPE ratio below 0.9461 as calculated in 2.2

Frequency Band	Mode	Frequency Range (MHz)	Reference frequency (Lowest freq.) (MHz)	Maximum conducted output power (per tune-up) Pin (dBm)	TX slots	Duty cicle (%)	Evaluation distance R (cm)	Antenna gain (dBi)	S (mW/cm^2)	MPE limit in USA (mW/cm2)	MPE limit in Canada (mW/cm2)	Worst case MPE limit	MPE Ratio (S/MPE limit)
2,4 ISM	**WiFi 2.4 GHz (802.11b)**	2412 - 2462	2412,0	19,32	N/A	100,0%	20	2,30	0,0289	1,0000	0,5366	0,5366	0,0539
GSM 850	**GSM/GPRS (class 10)**	824,2 - 848,8	824,2	32,50	2	25,0%	20	4.37	0,2423	0,5495	0,2576	0,2576	0,9407

The sum of MPE ratios in this case is 0.0539 + 0.9407 = 0.9946

The sum of S for both modes is 0.0289 + 0.2423 = 0.2713 (mW/cm^2) → **S = 2.713 W/m^2**

In compliance with all limits of MPE, EIRP and MPE for working in co-location

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