RF Exposure Lab

802 N. Twin Oaks Valley Road, Suite 105 • San Marcos, CA 92069 • U.S.A.
TEL (760) 471-2100 • FAX (760) 471-2121
http://www.rfexposurelab.com

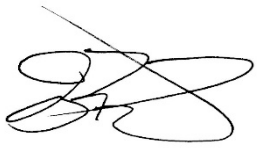
CERTIFICATE OF COMPLIANCE
SAR EVALUATION

Appareo Systems		Dates of Test:	December 9, 2022
1830 NDSU Research Circle		Test Report Number:	SAR.20221208
Fargo, ND 58102			Revision C
			Lab Designation Number: US1195

FCC ID:	2AETC-AEG95NAXD
Contains FCC ID:	2AETC-AFC20 & 2AETC-ABG772AGL
Model(s):	TCU-NA,V1
Contains Cellular Module:	Quectel Model EG95NAXD FCC ID: XMR202008EG95NAXD; IC: 10224A-021EG95NAXD and Model BG772 FCC ID: XMR2022BG6772AGL; IC: 10224A-2022BG772A
Contains WiFi/BT Module:	Quectel Model FC20 FCC ID: XMR201703FC20; IC: 10224A-201703FC20
Brand Name:	Polaris
Equipment Type:	Wireless Telemetric Control Unit
Classification:	Portable Transmitter
TX Frequency Range:	2402 – 2480 MHz; 699 -716 MHz; 777 – 787 MHz; 807 – 824 MHz; 814 – 849 MHz; 1710 – 1780 MHz; 1850 – 1915 MHz
Frequency Tolerance:	± 2.5 ppm
Maximum RF Output:	2450 MHz (BT) – 6.8 dBm, 2450 MHz (b) – 19.5 dBm, 2450 MHz (g) – 17.5 dBm, 2450 MHz (n) – 17.0 dBm, 5150-5825 MHz (a) – 15.0 dBm, 5150-5825 MHz (n) – 17.0 dBm, 802.11ac – 16.0 dBm, 700 MHz – 25.7 dBm, 850 MHz – 25.7 dBm, 1750 MHz – 25.7 dBm, 1900 MHz – 25.7 dBm Conducted
Signal Modulation:	BPSK, QPSK, CCK, 16QAM, 64QAM, 256QAM, 8PSK
Antenna Type:	Internal for Each Transmitter
Application Type:	Certification
Standard(s):	47CFR1.1310, 47CFR2.1093, KDB447498 D01 v06, KDB248227 D01 v02r02, KDB941225 D05 v02r05
Separation Distance:	92 mm

This wireless portable device has been shown to be excluded for RF exposure requirements for uncontrolled environment/general exposure limits specified in above listed standards for standalone SAR. The device has also been shown to meet the simultaneous requirements of each standard as well (See test report).

I attest to the accuracy of the data. I assume full responsibility for the completeness of these calculations and vouch for the qualifications of all persons making them.



Jay M. Moulton
Vice President

ACCREDITED
Certificate # 2387.01

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Comment/Revision	Date
Original Release	April 6, 2023
Revision A – Correct IDs for BG772 module, bands supported, maximum power and minimum distance	May 4, 2023
Revision B – Add FCC IDs to the report	May 10, 2023
Revision C – Remove the space in the model number	August 25, 2023

Note: The latest version supersedes all previous versions listed in the above table. The latest version shall be used.

1. Introduction

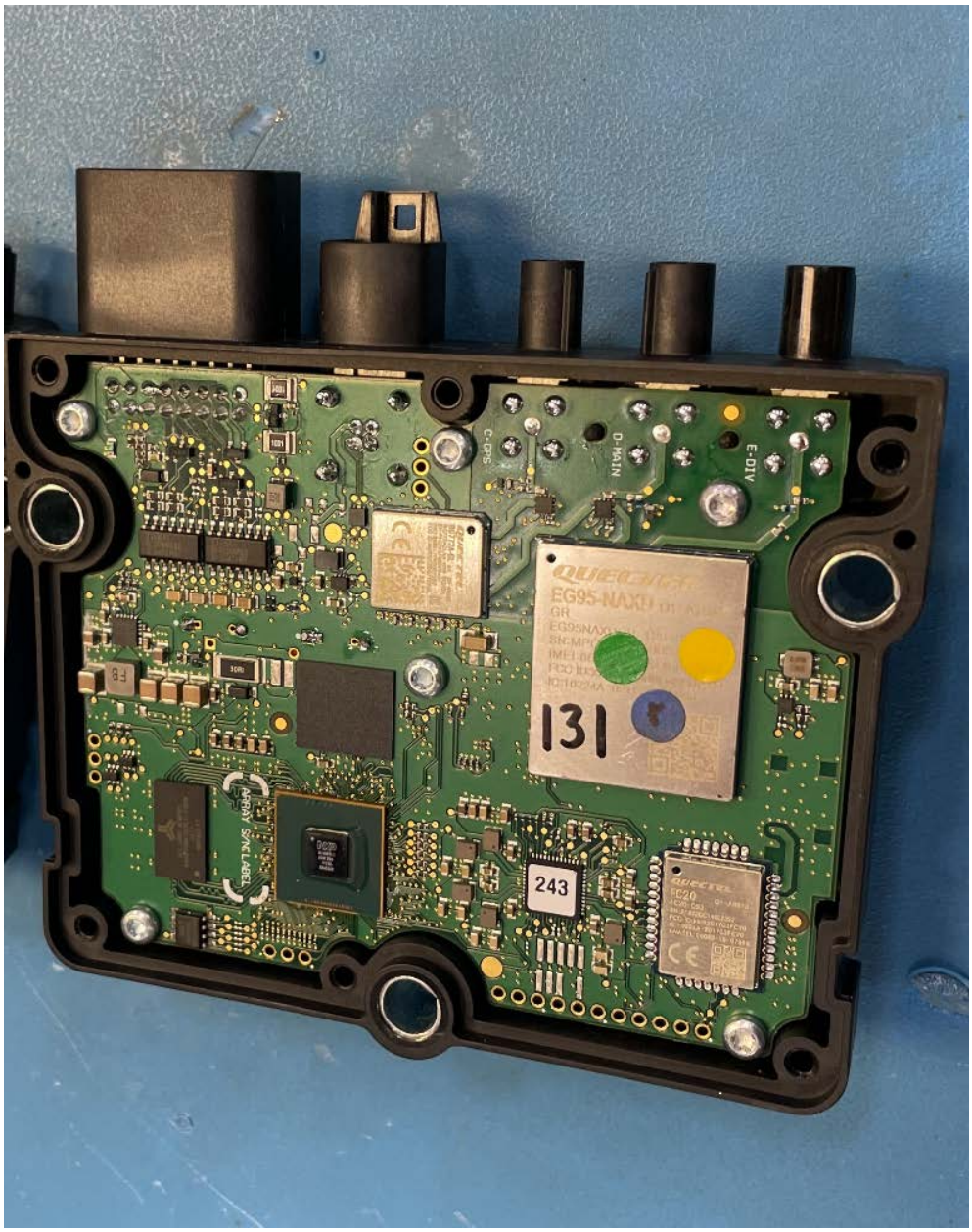
This report shows exclusion calculations of the Appareo Systems Model TCU-NA,V1 Wireless Telemetric Control Unit with 47CFR1.1310, 47CFR2.1093, KDB447498 D01 v06, KDB248227 D02 v02r02 and KDB941225 D05 v02r05.

The device can have one of two cellular modules installed. It can either have the Quectel EG95-NAXD or the Quectel BG772. It cannot have both cellular modules installed. The evaluation in the report is to cover both versions of the device.

2. Radiation Sources

Module	Band	Technology	Class	3GPP Nominal Power dBm	Setpoint Nominal Power dBm	Tolerance dBm	Lower Tolerance dBm	Upper Tolerance dBm
Quectel EG95-NAXD	Band 2	WCDMA	3	24.0	24.0	+1.0/-3.0	21.0	25.0
	Band 4	WCDMA	3	24.0	24.0	+1.0/-3.0	21.0	25.0
	Band 5	WCDMA	3	24.0	24.0	+1.0/-3.0	21.0	25.0
	Band 2	LTE-FDD	3	23.0	23.0	± 2.0	21.0	25.0
	Band 4	LTE-FDD	3	23.0	23.0	± 2.0	21.0	25.0
	Band 5	LTE-FDD	3	23.0	23.0	± 2.0	21.0	25.0
	Band 12	LTE-FDD	3	23.0	23.0	± 2.0	21.0	25.0
	Band 13	LTE-FDD	3	23.0	23.0	± 2.0	21.0	25.0
	Band 25	LTE-FDD	3	23.0	23.0	± 2.0	21.0	25.0
	Band 26	LTE-FDD	3	23.0	23.0	± 2.0	21.0	25.0
Quectel BG772	Band 2	LTE-FDD	3	N/A	N/A	N/A	N/A	25.7
	Band 4	LTE-FDD	3	N/A	N/A	N/A	N/A	25.7
	Band 5	LTE-FDD	3	N/A	N/A	N/A	N/A	25.7
	Band 12	LTE-FDD	3	N/A	N/A	N/A	N/A	25.7
	Band 13	LTE-FDD	3	N/A	N/A	N/A	N/A	25.7
	Band 25	LTE-FDD	3	N/A	N/A	N/A	N/A	25.7
	Band 26	LTE-FDD	3	N/A	N/A	N/A	N/A	25.7
	Band 27	LTE-FDD	3	N/A	N/A	N/A	N/A	25.7
	Band 66	LTE-FDD	3	N/A	N/A	N/A	N/A	25.7
Quectel FC20	2.4 GHz	802.11b	N/A	N/A	17.0	± 2.5	14.5	19.5
	2.4 GHz	802.11g	N/A	N/A	15.0	± 2.5	12.5	17.5
	2.4 GHz	802.11n	N/A	N/A	14.5	± 2.5	12.0	17.0
	2.4 GHz	802.11ac	N/A	N/A	13.5	± 2.5	11.0	16.0
	5 GHz	802.11a	N/A	N/A	12.5	± 2.5	10.0	15.0
	5 GHz	802.11n	N/A	N/A	14.5	± 2.5	12.0	17.0
	5 GHz	802.11ac	N/A	N/A	13.5	± 2.5	11.0	16.0
	2.4 GHz	Bluetooth	N/A	N/A	5.8	± 1.0	4.8	6.8

3. Photos



Internal Photo of Radio Module

External Photo of Device

4. RF Exposure Classifications

Device Types	
Fixed	A fixed device is defined as a device physically secured at one fixed location and cannot be easily re-located.
Mobile	A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. (47 CFR 2.1091)
Portable	A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user. (47 CFR 2.1093)

Exposure Categories	
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.
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 cannot exercise control over their exposure.

5. RF Exposure Limits Standalone And Simultaneous SAR

FCC Requirements

The FCC SAR test exclusion for standalone SAR is determined for each operating configuration and exposure condition the device can operate.

$$P_{th}(\text{mW}) = \begin{cases} ERP_{20\text{cm}}(d/20\text{ cm})^x & 0.5\text{ cm} \le d \le 20\text{ cm} \\ ERP_{20\text{cm}} & 20\text{ cm} < d \le 40\text{ cm} \end{cases}$$

$$x = -\log_{10}\left(\frac{60}{ERP_{20\text{cm}}\sqrt{f}}\right)$$

$$ERP_{20\text{cm}}(\text{mW}) = \begin{cases} 2040f & 0.3\text{ GHz} \le f \le 1.5\text{ GHz} \\ 3060 & 1.5\text{ GHz} < f \le 6.0\text{ GHz} \end{cases}$$

$$d = \text{separation distance (cm)}$$

For simultaneous evaluation, the sum of the individual SAR values of each of the transmitters must be less than the limit to comply. If the transmitter is excluded from SAR testing, the SAR value is estimated based on the formula below.

[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)] * [$\sqrt{f_{(GHz)}}$/x] W/kg, for test separation distances ≤ 50 mm;
Where x = 7.5 for 1-g SAR

6. Cellular Modem Specifications

The tolerance for the u-blox modem (EG95-NAXD) is 24 dBm +1.0/-3.0 dBm for WCDMA bands and 23 dBm ± 2.0 dBm for LTE bands. Therefore, the upper end of the conducted tolerance is 25 dBm (316.2 mW). The tolerance for the u-blox modem (BG772) is 23 dBm ± 2.7 dBm for the LTE Cat M1 bands. Therefore, the upper end of the conducted tolerance is 25.7 dBm (371.5 mW). The antenna gain for each band is a positive gain. The table below shows the gain for each band.

Modem	Band	Technology	Gain
Quectel EG95-NAXD	2	WCDMA	2.1 dBi
	4	WCDMA	2.1 dBi
	5	WCDMA	1.7 dBi
	2	LTE	2.1 dBi
	4	LTE	2.1 dBi
	5	LTE	1.7 dBi
	12	LTE	1.7 dBi
	13	LTE	1.7 dBi
	25	LTE	2.1 dBi
	26	LTE	1.7 dBi
Quectel BG772	2	LTE	2.1 dBi
	4	LTE	2.1 dBi
	5	LTE	1.7 dBi
	12	LTE	1.7 dBi
	13	LTE	1.7 dBi
	25	LTE	2.1 dBi
	26	LTE	1.7 dBi
	27	LTE	1.7 dBi
	66	LTE	2.1 dBi

Therefore, the radiated power level is used to calculate the exclusion.

7. WiFi/BT Modem Specifications

The tolerance for the Quectel modem (FC20) is 17 dBm ± 2.5 dBm for 2.4 GHz bands and 14.5 dBm ± 2.5 dBm for 5 GHz bands. Therefore, the upper end of the conducted tolerance is 19.5 dBm (89.1 mW) for 2.4 GHz and 17.0 dBm (50.1 mW) for 5 GHz. The antenna gain for each band is a negative gain. The table below shows the gain for each band.

Modem	Band	Technology	Gain
Quectel FC20	2.4 GHz	WiFi	-1.2 dBi
	5 GHz	WiFi	-0.6 dBi
	2.4 GHz	Bluetooth	-1.2 dBi

Therefore, the conducted power level is used to calculate the exclusion.

8. Standalone SAR Exclusion Assessment

FCC Requirements

Based on the formula in section 5, the exclusion calculation for each of the transmitters is listed below.

Quectel Model EG95-NAXD
All Low Bands = 26.7 dBm = 467.7 mW
All High Bands = 27.1 dBm = 512.9 mW

Quectel Model BG772
All Low Bands = 27.4 dBm = 549.5 mW
All High Bands = 27.8 dBm = 602.6 mW

Quectel Model FC20
2.4 GHz WiFi Band = 19.5 dBm = 89.1 mW
5 GHz WiFi Band = 17.0 dBm = 50.1 mW
2.4 GHz BT Band = 6.8 dBm = 4.8 mW

Quectel Model EG95-NAXD Exclusion Power Limits
750 MHz Bands – 552 mW
850 MHz Bands – 564 mW
1750 MHz Bands – 737 mW
1900 MHz Bands – 728 mW

Quectel Model BG772 Exclusion Power Limits
750 MHz Bands – 552 mW
850 MHz Bands – 564 mW
1750 MHz Bands – 737 mW
1900 MHz Bands – 728 mW

Quectel Model FC20 Exclusion Power Limits
2.4 GHz Bands – 537 mW
5 GHz Bands – 462 mW

Therefore, all transmitters are excluded from standalone SAR evaluations.

FCC Simultaneous Requirements

The cellular transmitter can simultaneously transmit with the WiFi transmitters. The cellular transmitter can also transmit simultaneously with the BT transmitter. The WiFi and BT cannot transmit simultaneously.

Since all transmitters are excluded from standalone SAR, each transmitter's SAR value is estimated using the formula in section 5 above. The estimated SAR value for each transmitter that can simultaneously transmit is listed below.

Quectel Model EG95-NAXD
750 MHz Bands – (467.7 mW / 92 mm) * (√0.787 / 7.5) = 0.60 W/kg
850 MHz Bands – (467.7 mW / 92 mm) * (√0.849 / 7.5) = 0.62 W/kg
1750 MHz Bands – (512.9 mW / 92 mm) * (√1.755 / 7.5) = 0.99 W/kg
1900 MHz Bands – (512.9 mW / 92 mm) * (√1.915 / 7.5) = 1.03 W/kg

Quectel Model BG772
750 MHz Bands – (549.5 mW / 92 mm) * (√0.787 / 7.5) = 0.71 W/kg
850 MHz Bands – (549.5 mW / 92 mm) * (√0.849 / 7.5) = 0.73 W/kg
1750 MHz Bands – (602.6 mW / 92 mm) * (√1.755 / 7.5) = 1.16 W/kg
1900 MHz Bands – (602.6 mW / 92 mm) * (√1.915 / 7.5) = 1.21 W/kg

Quectel Model FC20
2.4 GHz Bands – (89.1 mW / 80 mm) * (√2.462 / 7.5) = 0.23 W/kg
5 GHz Bands – (50.1 mW / 80 mm) * (√5.825 / 7.5) = 0.20 W/kg

The worst case value was calculated from all the bands within the frequency listed for each module.

The sum of worst case value for the EG95-NAXD & WiFi is 1.26 W/kg and the sum of the worst case value for the BG772 & WiFi is 1.44 W/kg. The sum for both configurations is less than the limit of 1.6 W/kg. Therefore, the device meets the simultaneous requirements.