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FCC RF Exposure Information Per KDB 447498

Operational Description

The BI LOC8 Tracker is an ankle-worn tracking device. The unit utilizes GPS data and other location monitoring technologies to accurately track an offender moving within local communities. The maximum transmission rate is once per minute with duration of 3 seconds but only occurs when the offender is in violation.

RF Exposure Conditions

The BI locator ankle-worn tracking device is intended for operation in the general population / uncontrolled RF exposure environment. Three radios are incorporated into this device as follows:

- a CDMA cellular transmitter.
- a Part 15.231 periodic transmitter (Shield Detect Transmitter) for detecting attempts to shield the device.
- a WiFi transmitter

Antenna Separation Distances

- ~8.39 mm to Ankle (cellular)
- ~5 mm to Ankle (shield detect)
- ~14mm to Ankle (WiFi)

Transmission Mode

The tracker utilizes an internal CDMA cellular transmitter (FCCID: R5Q-LISAC200A), Bluegiga WiFi transmitter (FCCID: QQQWF121), and Part 15.231 periodic transmitter (FCCID: CSQ-LOC8) for detecting attempts to shield the device.





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Cellular Radio Duty Cycle

The device has a **maximum** transmission rate of once per minute. The on-air transmission time is 3 seconds. This leads to a worst case on-air duty cycle of 5%.

Information regarding the worst case duty cycle was provided by the host manufacture BI.

Worst Case Duty Cycle

Duty Cycle = Transmission Time / TOTAL Time = 3s/60s = 0.05

Duty Cycle = 5%

Justification for 5% Maximum Duty Cycle (Information provided by BI):

In this application, the cell module is used to communicate location data from the tracking device to a host computer. The location data points can be acquired at variable rates, the maximum rate being 4 points per minute and the typical rate being 1 point per minute. The maximum call rate occurs when the client is in an exclusion zone, and the location information is communicated to the host once each minute. Under normal conditions, location information is acquired once each minute, and the data is communicated to the host at longer intervals, say, 15 minutes or 1 hour. The highest duty cycle will occur when only 4 location points are called in once each minute, since message overhead remains relatively fixed, regardless of the number of location points per communication session. All location point acquisition rates and call-in frequency are determined by the firmware that controls the tracker operation.

The maximum duty cycle occurs when the unit is calling in 4 location points at the minimum reporting time of 1 minute. The time for this communication with the host is 3 seconds maximum, resulting in a maximum connect time duty cycle of 5 percent.

This duty cycle was derived by measuring multiple message connection times at the host for the 4-location points-per-minute being called in to the host once each minute. This maximum measured connection time was 3 seconds. In contrast, the connection time for a message containing 29 location points, called in after 29 minutes of gathering this data, was 8 seconds (0.46% duty cycle), thus verifying the highest duty cycle occurs at a 1-minute call-in window.





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Wi-Fi Radio Duty Cycle

WiFi radio has a **maximum** transmission rate of 2 milliseconds per second. Therefore the worst case duty cycle for this radio is 0.2%

Information regarding the worst case duty cycle was provided by the host manufacturer BI.

Worst Case Duty Cycle

Duty Cycle = (Transmission Time / TOTAL Time) X 100 = (.002s/1s) X 100 = 0.2%

Justification for the Maximum Duty Cycle for the LOC8 Wi-Fi Radio

The Bluegiga WF121 Wi-Fi module located in the LOC8 is used to determine if the client wearing the LOC8 Tracker is within a short distance of a stationary device (Beacon) placed at known locations, for example, the client's home or workplace. In this operating mode of concern here, the LOC8 will transmit a probe request, and then listen to see if an assigned Beacon responds. The LOC8 will transmit the probe once every 30 seconds, typically, but it will be possible for it to transmit the probe once every second. This duty cycle is controlled by the LOC8 firmware.

The maximum RF ON time during a probe transmission is 2 milliseconds. This time was confirmed by measurement using a spectrum analyzer operating in zero-span mode. Three sweep time settings were used to confirm the pulse width and that no other transmissions occurred in the one second following the probe transmission.





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Standalone SAR Exclusion Threshold for Low Duty Factor Device

The maximum power used for calculations below is based on the maximum power stated by Ublox for the cellular module which includes tune-up tolerance.

CDMA Mode – Cellular 850 Band

Maximum Measured Conducted Output Power = 289mW

Worst Case Duty Cycle – 5.0 %

Worst Case Source Based Time Averaged Output Power = 289mW x 0.05 = 14.45mW

Exclusion Threshold Calculation from KDB 447498 - $[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \times \sqrt{f(\text{GHz})} \leq 7.5$ (10-g extremity exclusion threshold)

Calculation for Worst Case Duty Cycle = $(14/8) \times \sqrt{0.849} = 1.6$

CDMA Mode – PCS 1900 Band

Maximum Measured Conducted Output Power = 234mW

Worst Case Duty Cycle – 5.0 %

Worst Case Source Based Time Averaged Output Power = 234mW x 0.05 = 11.7mW

Exclusion Threshold Calculation from KDB 447498 - $[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \times \sqrt{f(\text{GHz})} \leq 7.5$ (10-g extremity exclusion threshold)

Calculation for Worst Case Duty Cycle = $(12/8) \times \sqrt{1.91} = 2.1$

Shield Detect Transmitter – 433.92 MHz ISM Band

Per FCC 2.1093 radios that operate under rule part 15.231 are categorically excluded from routine environmental evaluation for RF exposure prior to equipment authorization or use, except as specified in 1.1307(c) and 1.1307(d).

Wi-Fi Transmitter

Maximum Output Power (from module RF Exposure analysis exhibit) = 131mW

Transmission On Time = 2mS

Worst Case Interval = 1 second

Duty Cycle = $(.002\text{S} / 1\text{S}) \times 100 = 0.2\%$

Source Based Time Averaged Output Power = 131mW x 0.002 = 0.262mW

Exclusion Threshold Calculation - $[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \times \sqrt{f(\text{GHz})} \leq 7.5$ (10-g extremity exclusion threshold)

Exclusion Threshold Calculation = $(0.262/14) \times \sqrt{2.462} = 0.0294$





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Simultaneous Transmission SAR Considerations

Per paragraph 5.3 of KDB447498 since the maximum duration of overlapping transmissions including network hand-offs is less than 30 seconds, the simultaneous transmission consideration is not technically required. Nevertheless, below, the calculations show that the simultaneously transmitting radios meet the exemption criteria.

The only simultaneous transmission condition that applies is when the cellular and Wi-Fi radios are transmitting simultaneously. The shield detect and cellular radio do not transmit simultaneously. The shield detect and Wi-Fi radios do not transmit simultaneously. The cellular transmitter cannot transmit in CDMA Cell and CDMA PCS bands simultaneously.

From KDB447498 Section 4.3.2 (2), when the standalone SAR test exclusion of section 4.3.1 is applied to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to the following to determine simultaneous transmission SAR test exclusion:

(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm) $\cdot\sqrt{f(\text{GHz})/x}$ W/kg for test separation distances ≤ 50 mm

The standalone SAR for each simultaneously transmitting radio is estimated below using the equation above:

Standalone SAR Estimation for Cellular Radio (850 Band)

$$(14.45\text{mW} / 5\text{mm}) \times (\sqrt{[0.849]} / 18.75) = 0.107 \text{ W/kg}$$

Standalone SAR Estimation for Cellular Radio (PCS 1900 Band)

$$(11.7\text{mW} / 5\text{mm}) \times (\sqrt{[1.91]} / 18.75) = 0.173 \text{ W/kg}$$

Standalone SAR Estimation for Wi-Fi Radio

$$(0.262\text{mW} / 5\text{mm}) \times (\sqrt{[2.462]} / 18.75) = 0.004 \text{ W/kg}$$

From KDB447498 Section 4.3.2, when the sum of 1-g or 10-g SAR of all simultaneously transmitting antennas in an operating mode and exposure condition combination is within the SAR limit, SAR test exclusion applies to that simultaneous transmission configuration. The calculations below show clearly that the sum of the standalone SARs for the WiFi + Cellular 850 radios as well as WiFi + PCS1900 radios is below the 10g SAR limit (4W/kg).

WiFi + Cellular 850 Radio

$$0.004\text{W/kg} + 0.107\text{W/kg} = 0.111\text{W/kg}$$

WiFi + PCS1900 Radio

$$0.004\text{W/kg} + 0.173\text{W/kg} = 0.177\text{W/kg}$$





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Conclusion

Since the standalone SAR exclusion exemption levels are met for each radio on board, and the simultaneously transmitting radios also meet the appropriate exemption criteria, the BI LOC8 Tracker device is exempted from SAR testing.

