Test Report 23-077
Biotage® Liquid Level Sensor
Antenna Gain & EIRP

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1 Summary

From a regulatory perspective the Biotage® Liquid Level Sensor (LLS) must comply with certain radio frequency standards. Two important properties from a safety perspective are the *antenna gain* and the *transmitter output power.* Both properties determine how strong radio signal output is possible. Through measurements the antenna gain is approximated to 14 dBi and the peak Effective Isotropic Radiated Power (EIRP) to 18 dBm.

2 Scope

Approximating LLS total antenna gain and EIRP through measurements. Antenna gain is the combined gain from the integrated antenna and the lens. Peak EIRP is the effective peak power output of antenna and transmitter combined.

3 Background

The Biotage® LLS is a radar sensor operating at 57-61 GHz frequency using pulse modulation to detect liquid levels in solvent containers.

3.1 Radar chip

The sensor uses Acconeer's A111 radar chip which utilizes an Antenna in Package (AiP) technology. This means that the transmitter and antenna are integrated in the same chip and cannot easily be separated. Nominal values of the chip are found in Table 1.

Item	Value	Source
Transmitter output power	10 dBm	[1]
Antenna gain	6 dBi	[2]

Table 1. Acconeer A111 radar output properties.

3.2 Lens

The sensor uses a Fresnel Zone Plate (FZP) lens integrated into the sensor housing.

3.3 References

No.	Title	Source
[1]	A111 Datasheet	developer.acconeer.com/download/a111-datasheet-pdf/
[2]	Antenna Datasheet v1.1	-

4 Equipment and methods

The antenna gain is defined as the total gain stemming from the integrated radar chip antenna in combination with the FZP lens integrated in the Sensor housing. Or, as an equation:

$$G_{total} = G_{antenna} + G_{lens} \quad (1)$$

Where $G_{antenna}$ is 6 dBi found in [2] and G_{lens} is calculated according to:

$$G_{lens} = 0.5 * 20 * log10 * \frac{Amplitude_{Lens}}{Amplitude_{no\ Lens}} \quad (2)$$

Where amplitude with and without lens is measured with an LLS connected to an LLS hub through UDP-test. To measure the amplitude the sensor was aimed at an aluminum cylinder

with a circumference of 50 mm at a distance of 300 mm. The amplitude was measured with and without the housing with integrated lens.

Peak EIRP is approximated according to:

$$EIRP_{peak} = P_{transmitter} + G_{lens} \quad (3)$$

5 Results

As the measured amplitude fluctuates over time, an average during a 10 s period was used. Measuring the amplitude yielded the following:

- Without lens: 400 units
- With lens 2500 units

With this as input to Equation (2) the following gain is obtained:

$$G_{lens} = 10 * log10 * \frac{Amplitude_{Lens}}{Amplitude_{no\ Lens}} = 10 * log10 \left(\frac{2500}{400}\right) = 7.96 \approx 8\ \text{dB}$$

Which then in turn is used as input to Equation (1) results in a total gain of:

$$G_{total} = G_{antenna} + G_{lens} = 8 + 6 = 14\ dBi$$

Finally Peak EIRP is approximated through (3) as:

$$EIRP_{peak} = P_{transmitter} + G_{lens} = 10\ dBm + 8\ dB = 18\ dBm$$

6 Discussion and conclusion

In conclusion, through measurements the following is approximated:

- Antenna gain: $G_{total} \approx 14$ dBi
- $EIRP_{peak} \approx 18$ dBm