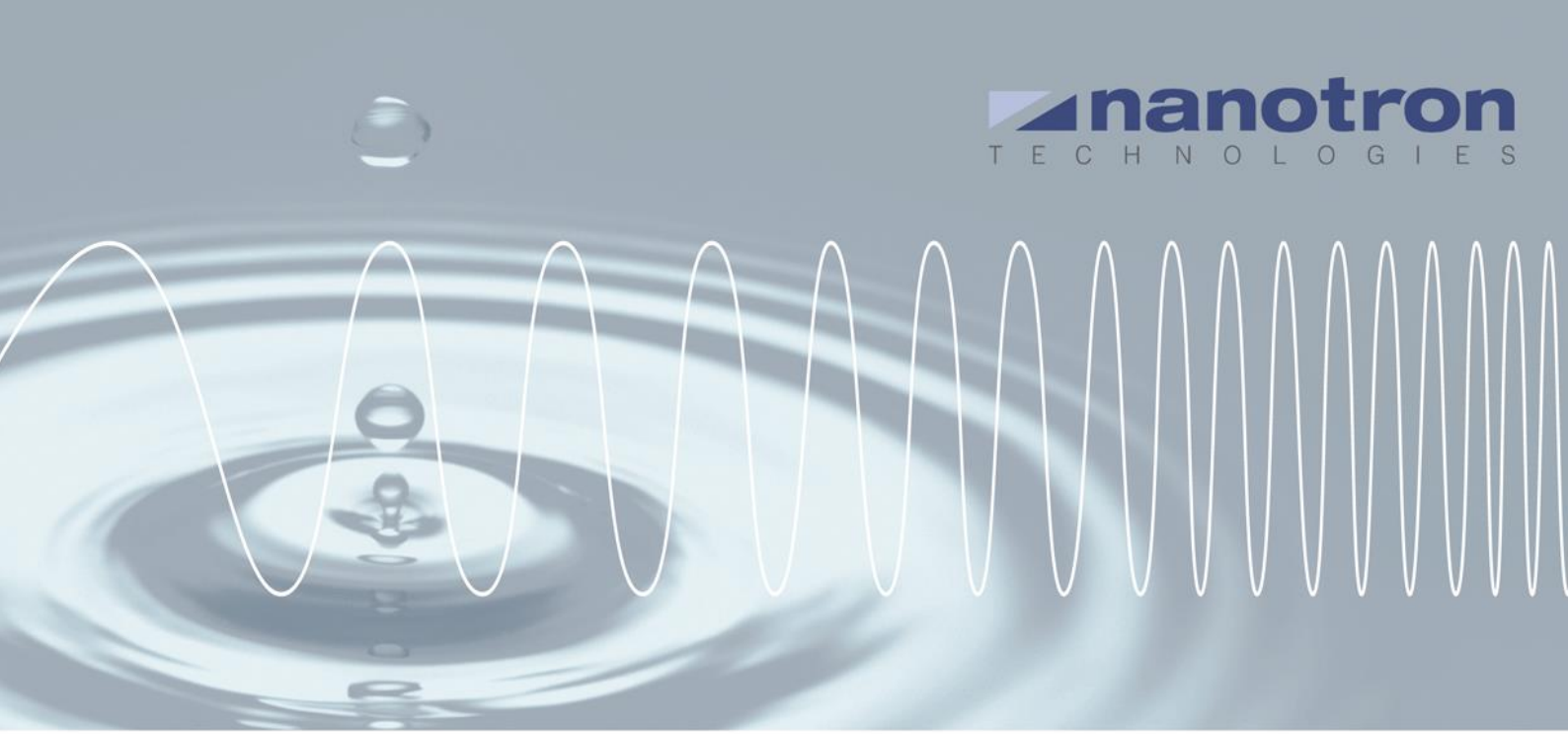

AN0529 Integrating *swarm* bee LE into a Cap Lamp

1.1

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Contents

1. Introduction

A very popular application of *swarm* bee LE is to integrate it into a cap lamp (see Figure 1-1). The cap lamp, carried by underground workers, can be used as a tag in a real time location system (RTLS) and collision avoidance solutions (CAS).

Figure 1-1 Sample cap lamp

To make a proper design of the tag, some aspects must be taken into consideration, especially housing and antenna. In the following, these two aspects are discussed separately.

Note: Please refer to [1] for more information about general tag designs.

2. Housing

The traditional cap lamp (see Figure 2-1) consists of the lamp, a ruggedized cable and a battery pack. The most popular solution for tag integration is targeting the battery pack. Space can be usually found to put the *swarm* bee LE module on a carrier board.

Figure 2-1 Traditional cap lamp design

Recently cordless cap lamp (see Figure 2-2) has become more popular. Their mechanical design usually does not provide extra space for any additional electronics. Hence a mechanical redesign will very likely be required.

Figure 2-2 Sample cordless cap lamp tag (3D printing model)

Note: Enough space for antenna and *swarm* bee LE module must be planned during design of the housing.

3. Antenna

Typical characteristics of an antenna are radiation pattern (see Figure 3-1) and antenna gain. For proper radiation the antenna must be matched to a 50 Ohm impedance at the RF port. In addition, a specific antenna might require certain spacing from the enclosure or any other components of the cap lamp, e.g. reflector, cable and battery etc.

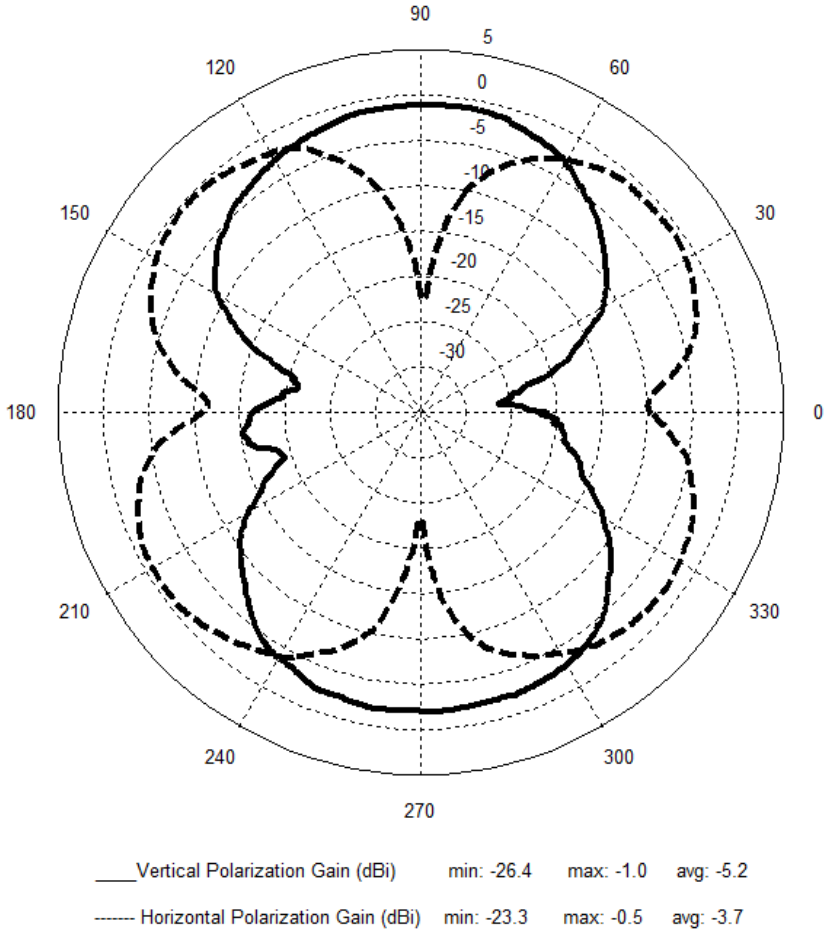

Figure 3-1 Sample radiation pattern of FlexNotch™ [5]

The reflector of the cap lamp will certainly prevent the RF signal from going out (Faraday cage). Therefore, specific care needs to be taken to select a suitable position relative to the reflector.

Theoretically, the omnidirectional pattern is the ideal radiation pattern to optimize the tag performance. However, in reality it is not possible to achieve. Therefore, the radiation pattern must be optimized such that

it comes closest to the ideal when the cap lamp is worn in its preferential position, e.g. straight up on the helmet.

It is very difficult to provide general recommendations on antenna types and their most suitable position. Each lamp design has its own constraints. Below we are providing some examples for antenna that have worked well in some cases but may not work at all in others. It is highly recommended to characterize the radiation pattern of the chosen antenna solution before signing it off for production. If your team is not familiar with RF or has only limited experience with solutions for 2.4 GHz, a specialized consultant might be the best option.

3.1. Stickable Band Antenna

Figure 3-2 shows a kind of stickable antenna FXP.74 from Taoglas, which can be mounted easily by simply “peeling and sticking”. The FXP.74 is the ideal all-round antenna solution for fitting into narrow spaces and still maintaining high performance, for example on the inside top or adjacent side applied directly to the plastic housing of LCD monitors, tablets, smartphones, small AP routers, etc.

Figure 3-2 Stickable band antenna from Taoglas

Table 3-1 shows the key features of this antenna. For more information please refer to the datasheet which is available here [2].

Note: Antenna-specific parameters and values mentioned in this document are given as provided by the respective manufacturer. Nanotron does not assume any responsibility for completeness or correctness.

Parameter	Value
Communication System	Bluetooth, Wi-Fi, ZigBee, 2.4 GHz ISM
Efficiency	50%
Gain	4 dBi
Return Loss	< -10 dB
Impedance	50 Ohms
VSWR	≤ 2:1
Polarization	Linear
Power Handled	5 W
Dimensions	47 mm x 7 mm x 0.1 mm
Weight	1.2 g
Connector	MHFI (U.FL compatible)
Cable Standard	Mini-Coax 1.13 mm
Cable Length & Color	100 mm, Black
Adhesive Tape	3M 467
Operation Temperature	- 40 °C ~ +85 °C

Table 3-1 Key features of FXP.74

3.2. Mini PCB Antenna

The antenna in the figure below is a kind of mini PCB antenna from RF Solutions. It is supplied with a U.FL connector and 3M adhesive fixing for mounting on any non-conductive surface, e.g. plastic. Figure 3-4 shows one example of mounting the antenna.

Figure 3-3 mini PCB antenna from RF Solutions

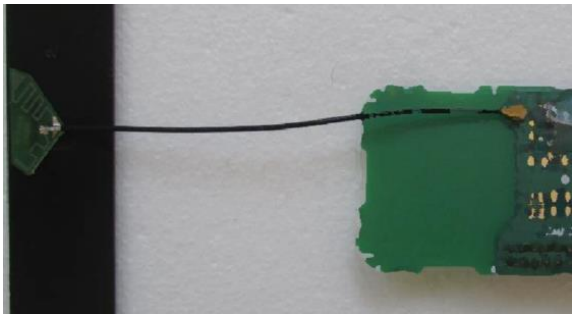

Figure 3-4 Mounting of mini PCB antenna

Parameter	Value
Frequency Range	2400 – 2486 MHz, 5150 – 5875 MHz
Gain	3 dB
Return Loss	< -10 dB
Impedance	50 Ohms
VSWR	< 3.0 @ 2400 – 2485 MHz, 5150 – 5350 MHz
	< 4.0 @ 5350 – 5875 MHz
Dimensions	27 mm x 12 mm x 1 mm
Weight	1 g
Connector	U.FL
Cable Standard	Mini-Coax 1.13 mm
Cable Length & Color	100 mm, Black
Adhesive Tape	3M 467
Operation Temperature	- 30 °C ~ +85 °C

Table 3-2 Key features of mini PCB antenna

Common applications of this antenna are: WLAN, M2M communications, automated meter reading. For more information please visit the website of the manufacturer [3].

3.3. Thin PCB Antenna

Another PCB antenna is a thin PCB antenna as shown in Figure 3-5 from TE (Tyco Electronics Corporation). With relative large mounting area, this antenna can be sticked directly onto a PCB ground plane.

Figure 3-5 Thin PCB antenna

Parameter	Value
Frequency Range	2300 – 3800 MHz, 5150 – 5875 MHz
Gain	2 dBi
Feed Point Impedance	50 Ohms unbalanced
VSWR	≤ 3 :1
Polarization	Linear
Azimuth Beamwidth	Omni-directional
Power Handled	3 W
Dimensions	30 mm x 41 mm x 0.3 mm
Weight	< 3.3 g
Connector	U.FL
Cable Diameter	1.37 mm
Cable Length & Color	350 mm, Black
Adhesive Tape	3M VHB

Table 3-3 Key features of thin PCB antenna

For best performance follow Mounting Guide and Keep Out Area on data sheet which is available here [4].

3.4. Flexible Notch Antenna

FlexNotch™ from LSR is an adhesive-backed, flexible notch antenna that can be easily custom-trimmed for maximum range within specific enclosure (e.g. with convex or concave surface).

FlexNotch™ can be installed on flat or curved surfaces and flexed either in concave or convex directions without sacrificing antenna performance. One example of mounting this antenna on a concave surface is shown in Figure 3-6.

Figure 3-6 FlexNotch™ from LSR

Parameter	Value
Frequency	2400 – 2480 MHz
Efficiency	>-1.5 dB
Gain	2 dBi
Return Loss	< -10 dB
Impedance	50 Ohms
VSWR	< 2.5 :1
Polarization	Linear
Dimensions	32 mm x 21.1 mm
Weight	0.85 g
Connector	U.FL
Antenna Color	Clear yellow
Adhesive Tape	3M 100MP
Operation Temperature	- 40 °C ~ +85 °C

Table 3-4 Key features of FlexNotch™

For more information about FlexNotch™ regarding radiation pattern, mounting recommendations etc. please refer to the data sheet here [5].

4. Discussion

In the previous chapter several antennas were introduced. There are plenty of other antenna options which may suit the tag design with cap lamp.

Based on the various antenna characteristics and constraints from the reflector, battery and housing different antenna types could be more suitable for different cap lamp designs. Therefore, we suggest to consult an antenna expert early in the cap lamp integration project.

5. References

[1] AN0504 – Tag Design with *swarm* bee LE, Nanotron Technologies GmbH
[2] http://www.taoglas.com/antennas/GSM-CDMA-Cellular/Internal_Flexible_PCB_antennas_-_FXP_Series/
[3] http://www.rfsolutions.co.uk/acatalog/info_ANT_INSIDE_WLAN.html
[4] http://www.te.com/usa-en/product-2118060-1.html#pdp-docs-features
[5] https://www.lsr.com/downloads/products/330-0150.pdf

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Further Information

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