Preliminary Study of Shielding of 802.11ah

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***Abstract*—This work is a preliminary study aimed at discussion and simple comparison of two ways of shielding against eavesdropping of wireless communication under new standard IEEE 802.11ah between electrical devices included in the rapidly growing Internet of Things. This security problem could be solved with a special selective surface which is proposed in this document.**

***Keywords*–IEEE 802.11ah; Internet of Things; Shielding; Eavesdropping**

I. Introduction

The standard from the Institute of Electrical and Electronics Engineers (IEEE) with the label of 802.11ah [1] is a quite hot topic in the field of the Internet of Things (IoT). For the purpose of communication between even very small electrical appliances this represents a very new and efficient way of communication [2].

The world of IoT is full of electrical sensors, accessories, wearables, security elements, various appliances utilizable in Smart Home (for instance lighting, cooking, heating) and also agriculture monitoring, industrial automation and smart metering. The number of mentioned devices is supposed to raise rapidly in the near future what is related with significant security risks.

Therefore, the main goal of this preliminary study is aimed at analysis of possible ways of shielding communication under this standard against eavesdropping outside a room or a building.

This study is partially based on the previous work [3] where the goal was to reflect wireless communication under standard IEEE 802.11b,g. The final computed results of the optimized structure reflecting 2.4 GHz wireless communication are presented in Fig. 1.

This article includes the following content: Section II contains a brief description of IEEE 802.11ah. In Section III, some possible ways of shielding of this type of wireless communication are described. Finally, Section IV concludes ideas and ways mentioned in this preliminary study.

II. IEEE 802.11ah

The IEEE standard of 802.11ah, also called "Wi-Fi HaLow", has a great potential of usability in the area of IoT because of two main reasons [4]:

- Low power consumption thanks to a native power saving mechanism with sleep modes (should consume much less energy than Bluetooth or Wireless-Fidelity (Wi-Fi) of earlier standards b, g, a or n)

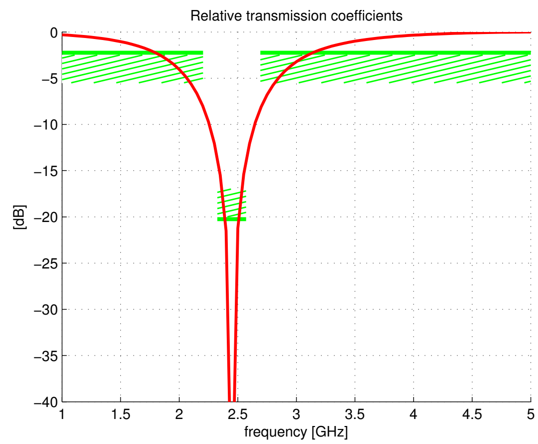

Figure 1. Transmission coefficients of the optimized FSS Wi-Fi filter [3].

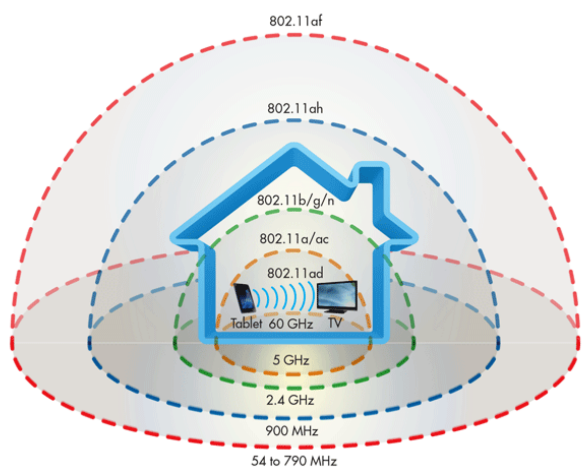

Figure 2. Comparison of different Wi-Fi ranges [2].

- Long range (can penetrate walls much more easily), the penetration and range of various Wi-Fi standards is depicted in Fig. 2.

Both items mentioned above are based on the key technological features of IEEE 802.11ah [5]:

- Sub 1 GHz frequency
- Design of new Physical Layer (PHY layer) and Media Access Control Layer (MAC layer). These new layers

include several modifications with respect to consolidated IEEE standards. The IEEE 802.11ah MAC layer incorporates most of the main IEEE 802.11 characteristics, adding some novel power management mechanisms.

- Typical range of IEEE 802.11ah is 100 – 1000 m
- Transmission power is <10 mW – <1 W (depending on the country's regulations)
- Battery operation should be from months to years (also thanks to long sleeping periods)

The mentioned standard is very new. It was standardized and introduced only few months ago, in January 4 2016 [1] (the first IEEE 802.11 standard was released in June 1997). The first certified devices should come soon (probably in 2017 or 2018). Due to these data, the topic of this study is unique and potentially very important and interesting from the point of view of secure communication.

III. SHIELDING

Considering wireless communication between electrical sensor or general devices using IEEE 802.11ah, the first idea of how to shield a communication in a room, in a small building or area is to use

A) A Faraday cage or
B) A wallpaper reflecting only a specific frequency range.

A. Faraday Cage

Faraday cages are named after the English scientist Michael Faraday. Faraday shield (cage) is an enclosure made from a conductive material or by a mesh of such material to block electric fields.

These shields – cages can be used to protect different kinds of electronic equipment from electrostatic discharges. They cannot block magnetic fields like Earth's magnetic field, but they can protect the interior from electromagnetic radiation coming from the outside. An external electrical field leads to rearrangement of the charges, and this cancels the field inside. Electric fields (applied externally) create forces on electrons in the conductor, creating a current, which will further result in charge rearrangement. The current will cease when the charges rearrange and the applied field inside is cancelled [6].

This approach is cheap but has several very negative side effects. First of all, whole frequencies coming to or from a cage are reflected, generally:

- Global System for Mobile (GSM) [7]
- Universal Mobile Telecommunications System (UMTS) [8]
- Long-Term Evolution (LTE) [9]
- 2.4 and 5 GHz Wi-Fi [4]
- Bluetooth [5]
- and possibly also the visible light if not using a mesh

This approach may go against the original aim to use IEEE 802.11ah in longer distances.

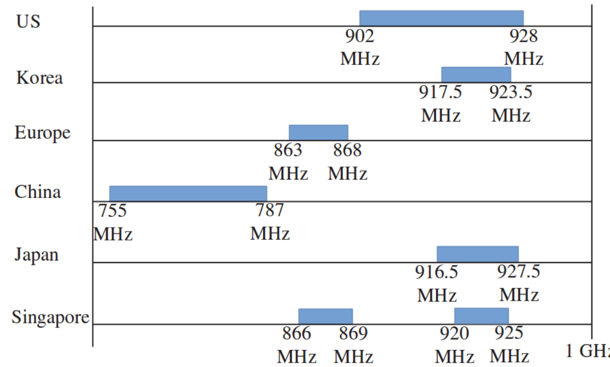

Figure 3. Sub 1 GHz spectrum specified in the IEEE 802.11ah channelization [16].

B. FSS

Frequency Selective Surfaces (FSSs) [10] are important spatial filters, which can efficiently filter desired band of frequencies. Therefore, these can play a significant role in electromagnetic related problems.

Frequency selective surfaces can be used and adjusted to prepare a structure reflecting just a desired narrow range of a spectrum.

To briefly sketch the history, the beginning of FSS relates to Ben A. Munk who was the guru of this approach [10]. In the last decade, the idea of FSS has spread out into many applications. Example of a band-pass FSS is in [11] where the goal was to transmit GSM signals through energy efficient windows. One of the first FSS absorbers was presented by Salisbury and Jaumann [12]. Great research has been already done in the field of FSS including also the analysis of frequency characteristics of dielectric period structures [13] and another analysis of characteristics of dielectric grating of left-handed and right-handed materials [14]. FSS are also used in the antenna theory and experiments like analysis of ultra wide band planar monopole antenna and its design [15].

This second idea of how to shield the communication is to use a special pattern/wallpaper selectively attenuating just the frequency range used in IEEE 802.11ah.

With respect to the design, rules and law of various countries the frequency range for Europe is 863 – 868 MHz (for example in USA it is 902 – 928 MHz and in China it is 755 – 787 MHz) [16]. Fig. 3 presents the ranges in more detail.

The standard of IEEE 802.11ah is operating in sub-gigahertz frequencies in comparison with traditional IEEE 802.11b or IEEE 802.11g working at 2.4 GHz and IEEE 802.11a working at 5 GHz.

The schema of a typical FSS structure: simple cross and a Jerusalem-cross is presented in Fig. 4. Both models consist of simple rectangular elements. Theoretically, the second geometry may have better reflection. Moreover double-layer should provide a more narrow band-stop filter.

In Fig. 4, a and a_j represent the width and height of a cell (a cell is just one square element of the whole structure of FSS; index j relates to the structure depicted on the right: the Jerusalem-cross), l and l_j is the total width and height of

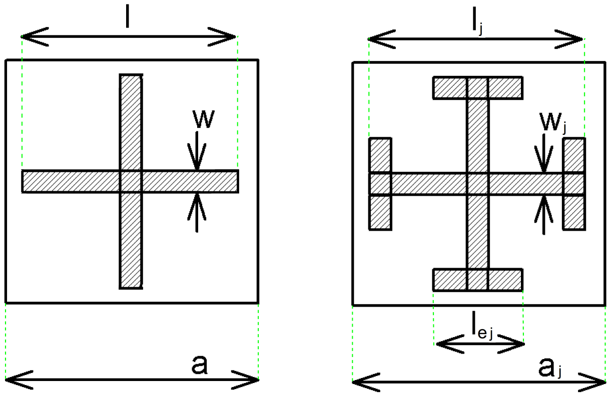

Figure 4. Schema of a cell containing the simple cross (on the left) and the Jerusalem-cross (on the right).

the cross, w and w_j is the width of an arm and l_{ej} represents the length of the bar connected to the end of an arm of the Jerusalem-cross.

There is also a special software suitable for optimization of FSS elements. It is FSSMR software [17], which was developed at Tomas Bata University in Zlin and which analyses the planar periodic structures and tries to optimize them with respect to the optimization goals. Therefore, this software is suitable for estimation of proper values of design variables (a, a_j, l, l_j, w, w_j, and l_{ej}) to meet the optimization goals (and thus to reflect the desired frequency band in this case of IEEE 802.11ah).

There are also some shortages in this approach. One of the most questionable aspects of the FSS approach is the influence of the angle of incidence which must be also examined. Another problem is with windows when attempting to secure a room against transmitting sub 1 GHz frequencies outside the room.

IV. Conclusion

A very new standard for wireless communication suitable for the Internet of Things, IEEE 802.11ah, has been introduced in this preliminary study together with possible ways of how to shield communication under mentioned standard. A theoretical concept of a wallpaper with a deep practical impact has been revealed. Also, some shortages of this approach have been described.

The boom of Internet of Things is coming. It can make life simpler (like other technologies in the history), but it also contains a great portion of a threat of abuse. This article points this out.

Further analysis, design of FSS filter with adaptation to the narrow specific range of frequencies and also practical experiments should be processed in further work.

Acknowledgment

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