Minimization of magnetoacoustic resonant tags for the electronic article surveillance system

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Abstract. The areas of application of EAS systems are, among others, stores and libraries. EAS systems are used to signal a theft of goods. The exemplary EAS system consists of: a transmitting antenna, a receiving antenna and tags also called clips. The tag is an element of the system with which the consumer has direct contact. The tag can be installed on various items available in the store. Starting from the size of a pen, through jackets and coats to TVs and bicycles. Therefore, the aesthetics, and mainly the size of the tag, cannot distort the consumer's ability to check an item accurately, nor can they affect its use. The paper presents a method of minimizing the dimensions of a tag while maintaining the required detection distance.

1 Electronic Article Surveillance

The EAS system is shown in Figure 1. Transmitting and receiving antennas are mounted at the exit of the protected zone in which protected goods with attached tags are located. Employees of the protected zone deactivate or remove tags when the item is properly purchased or rented. Otherwise, an alarm will be triggered when an active tag is near antennas [1].

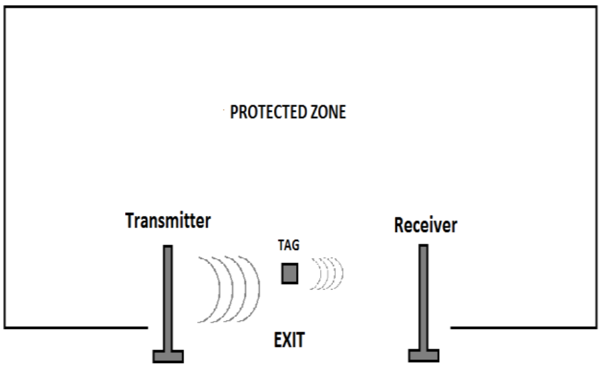

Fig. 1. Electronic Article Surveillance.

In the AM system, antennas have a relatively narrow band, around 600 Hz, and transmit a signal at 58 kHz [2]. The clip is made of a classic coil wound on a core and a capacitor. In contrast, labels are made of magnetostrictive material, this material shrinks under the influence of a magnetic field and a mechanical resonance occurs. The advantage of the AM system is the ability to activate or deactivate label by magnetising or demagnetizing ferromagnetic material contained in it. Deactivation does not damage a label.

2 Development of a reduced tag for the magnetoacoustic EAS

Two tag were tested for the detection distance and the results are shown in the graph (Fig. 2).

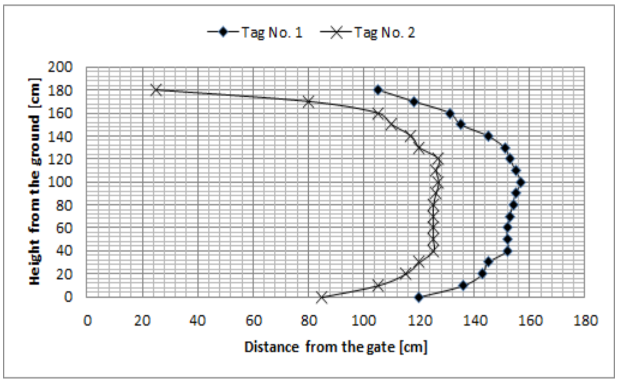

Fig. 2. Characteristics of the maximum distance between a tag and a gate at which a tag is detected.

The design of tag for the magnetoacoustic system was investigated. The resonant circuit consists of a coil wound on a core and a capacitor. The system is an LC resonant circuit. Measurements of electronic components and calculations of resonant circuit parameters were made. The results of measurements and calculations are given in Table 1.
The assumed accuracy of L and C components at the level of 0.5% results in the accuracy of the resonant frequency at the level of 0.5%, and thus the resonance frequency of the tags belongs to the antenna band.

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Table 1. Parameters of tags for the magnetacoustic system.

Parameter	Tag No. 1	Tag No. 2	Unit
Inductance of the coil	7.38	4.43	mH
Coil resistance	18.11	10.64	Ohm
Capacitor capacitance	1	1.77	nF
Number of coils	450	450	-
The length of the winding wire	10.8	7.7	m
Permanence AL	36.44	21.09	nH
The length of the core	39	28	mm
diameter of the core	6	4	mm
The length of the carcass	28	15	mm
The diameter of the carcass	7	5	mm
Cross-section of winding wire	0.0103	0.0124	mm2
Resonance frequency	58.59	57.89	kHz
Goodness of the coil	149.98	146.00	-
Bandwidth	390	400	Hz

3 Implementation of the resonant tag

The overview of magnetic materials was conducted and cores for building prototypes of tags were selected.

Due to the fact that available capacitor capacitance values are determined by series of types, another method for determining tag parameters has been proposed. For selected cores and for available capacitance values, the required inductance, the number of turns and the required winding resistance were determined, according to the formulas below.

Coil inductance:

$$L = \frac{1}{\left(2\pi f_0\right)^2 C}. \qquad (1)$$

where: f_0- resonant frequency, C – capacitor capacity.

Number of turns:

$$n = \sqrt{L / A_L}, \qquad (2)$$

where: A_L – core permeability.

Required coil winding resistance:

$$R = \frac{2\pi f_0 L}{Q}. \qquad (3)$$

where: Q – Required Q factor of the resonant circuit.

Selected examples of experimental designs of tags are shown in Figure 3.

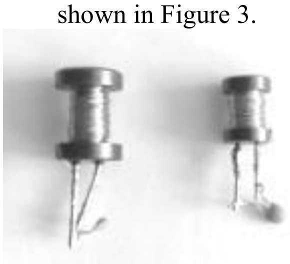

Fig. 3. Sample experimental designs tags.

The results obtained using the second method of parameters selection are presented in Table 2.

Table 2. Calculations of parameters for tags.

Core	Name		R-18	RS9	RS8
	Length	mm	19	12	10
	Diameter	mm	4	9/4/9	8/4/8
	Material		nn	AN65H	AN65H
	Permeance	nH	14.815	41.500	36.600
Winding wire	Diameter	mm	0.125	0.09	0.09
	Section	mm2	0.0123	0.00636	0.00636
	Resistance of the coil	Ohm	0.0236	0.0414	0.0408
Tag parameters	n		657	411	459
	L	mH	6.39	7.02	7.70
	C	nF	1.17	1.07	0.97
	R	Ohm	15.52	17.06	18.72
Core	Name		RW3/15	RW2/13	RW-4.0X20
	Length	mm	15	13	20
	Diameter	mm	3	2	4
	Material		AN25H	AN25H	E2D
	Permeance	nH	21.400	14.330	22.600
Winding wire	Diameter	mm	0.1	0.1	0.1
	Section	mm2	0.00785	0.00785	0.00785
	Resistance of the coil	Ohm	0.0307	0.0209	0.0368
Tag parameters	n		591	603	670
	L	mH	7.48	5.21	10.16
	C	nF	1.01	1.45	0.74
	R	Ohm	18.17	12.66	24.67

4 Summary

As part of the research, tests of electromagnetic and functional properties of tags designed for the AM system were performed based on currently available components. A mathematical model of the AM tag was developed and requirements for project purposes were defined. During laboratory work, experimental designs of selected AM tags were made and their tests were performed. Research confirms the thesis that there is the possibility of minimizing the tag.

References

1. Notes on Inductive RFID. https://www.coursehero.com/file/10179378/Notes-on-Inductive-RFID/
2. Electronic article Surveillance, https://en.wikipedia.org/wiki/Electronic_article_surveillance
3. K. Finkenzeller, RFID Handbook, 3rd ed. Oxford: Clarendon, 2010, pp.47-77.
4. J. Rathod, B. Bhumi, A Comparative Study of Electronic Article Surveillance (EAS) System., At International Conference on Signals, Systems & Automation (ICSSA-11), 2011.