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RESEARCH AND SOFTWARE OPTIMIZATION OF LASER VIBRATION SENSOR

Summary: the work is devoted to the principle action analysis of laser acoustic intelligence systems and passive methods of protection from reading acoustic information. The method of work with laser triangulation vibration sensors was described. The vibration sensor was configured and interface for working with spattered samples for passive protection was optimized.

Keywords: laser acoustic intelligence systems, laser, glass, vibration, passive protection, reflection, laser signal, counteraction to technical intelligence.

BADANIE I OPTYMALIZACJA ŚRODOWISKA OPROGRAMOWANIA LASEROWEGO CZUJNIKA DRGAŃ

Streszczenie: Praca naukowa poświęcona jest analizie zasad działania laserowych systemów rozpoznania akustycznego oraz pasywnych metod ochrony przed czytaniem informacji z ludzkiej mowy. Robota zbudowano wykorzystując technikę pracy z laserowymi czujnikami drgań triangulacyjnych. Czujnik drgań został dostrojony, a interfejs do pracy z rozpylonymi próbkami w celu ochrony pasywnej został zoptymalizowany.

Słowa kluczowe: Laserowe systemy rozpoznania akustycznego, laser, szkło, wibracje, ochrona pasywna, odbicia, sygnał laserowy, przeciwdziałanie rozpoznaniu technicznemu

1. Introduction

Long-range intelligence devices can be considered as one of the most dangerous electronic devices for the interception of acoustic information, because the attacker

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does not need an access to the room and he is easily able to get the information he needs. These include special laser microphones, and the information leakage channel of their use is called opto-electronic. These microphones are capable of capturing vibrations of glass and other shiny surfaces under the action of an acoustic field, and eventually convert those vibrations to the sound. Obtained acoustic information may contain commercial or even state secrets. Nowadays, protection against these devices is considered relevant, and the problem of information leakage using laser acoustic intelligence systems is a subject of research.

Thus, arises the question of developing a method and means of protection that can provide sufficient security of information, and at the same time an improvement in convenience of carrying out work and negotiations in the rooms with the use of less material and financial costs.

The research is that a new method of protecting acoustic information is proposed, which circulates indoors from the removal by means of Laser Acoustic Intelligence Systems. This method is different, because the problem of information removal is not solved by eliminating the possibility of a beam penetration on a vibrating surface or vibro-acoustic noise of this surface. It’s solved by the way of preventing or greatly complicating the interception of an attacker by an already reflected beam. This approach will allow to improve the comfort of work with a sufficient level of information security, as there is no need to install special vibro-acoustic protection devices on windows and other surfaces and, accordingly, additional background acoustic noises disappear. Also, the need of installing an optical opaque structures of metal shutter type which would constantly close windows during work or negotiations disappears.

1.1. Main part

The main advantage of LAIS over other intelligence tools is that they allow you to solve acoustic information capture tasks as safely as possible for an attacker, since the need to enter the rooms for the purpose of placing mortgages in there is excluded etc. LAIS in simplified form, consists of an infrared laser emitter and an optical receiver. The principle of operation of these devices is as follows. The laser emitter, with the help of an optical sight, is directed to a flat vibrating surface (the best example of such surface is the glass of a closed window of the room in which the conversation is held), the laser beam is then generated (high frequency signal), which spreads through the atmosphere and falls on this surface. It’s then reflected from the window glass and thus modulated by the law of an acoustic signal, which also affects the glass, reverses the atmosphere in the opposite direction and is received by the photodetector, which restores the information signal (fig. 1). When the laser beam is reflected from the vibrating surface, its frequency, angular and phase modulation occurs.

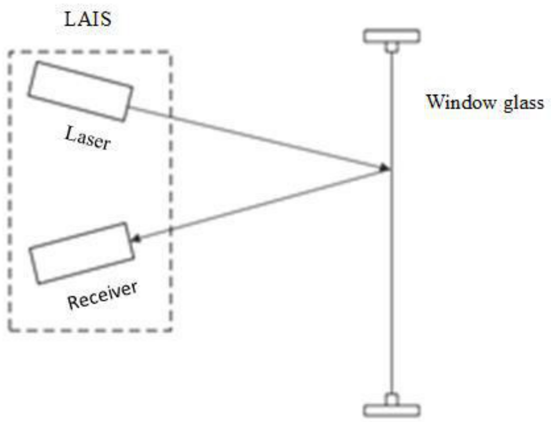

Figure 1. The principle of removing information from the window surface

Therefore, the principle of operation of such systems is based on the capture of vibrations through glass and other reflecting surfaces, where subsequently the oscillation is transformed into the sound. They allow you to intercept acoustic information from window glass and other reflective office objects over relatively long distances.

The basis of the sensor is based on the principle of optical triangulation (fig. 2).

The radiation of a semiconductor laser 1 is focused by the lens 2 on the object 6. Scattered on an object of radiation by lens 3 is gathered on CMOS ruler 4. Moving of an object 6 - 6 'causes the corresponding movement of the image. The signal processor 5 calculates the distance to the object by the position of the light spot image on the ruler 4.

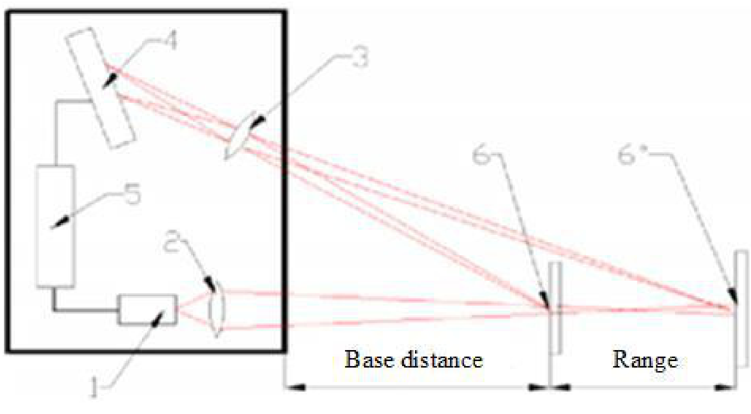

Figure 2. The principle of optical triangulation

Triangulation laser sensors are designed for proximity measurement and position monitoring, displacements, sizes, surface profile, deformations, vibrations, sorting, recognition of technological objects, measurement of the level of liquids and bulk materials.

The series includes 26 sensor models with a measuring range from 2 to 1250 mm and a base distance of 15 to 260 mm. All sensors are available in two versions - based on a red laser (660 nm) and based on a blue laser (405 or 450 nm, version BLUE). The use of blue lasers instead of traditional reds significantly enhances the capabilities of sensors, in particular, when controlling high-temperature objects as well as organic materials.

1.1.1. General installation requirements

The sensor is positioned so that the controlled object is located in the area of the working range of the sensor. In addition, there must be no foreign objects before the reflected and induced radiation area. (the required space for the installation of the sensors is shown in the table. 1).

During the control of complex shape and texture objects it is necessary to minimize the penetration of the mirror component of reflected radiation into the input window of the sensor. Dimensions of the laser spot for two variants (elliptical spot and round spot), as well as the parameters that characterize the required space for the passage of rays are included in the table.

Table 1. Required space for the installation of sensors

РФ603-	D, мкм			D1, мкм			D2, мкм			α, град	β, град	A, мм	B, мм
	SMR	MMR	EMR	SMR	MMR	EMR	SMR	MMR	EMR				
10/2	30	20	30	40	30	40	60	40	60				
39/4	110	140	110	90	110	80	190	470	80	38	42	27	37
15/5	100	40	100	200	60	200	300	80	300	45	53	15	25
15/10	250	50	250	350	80	350	700	90	700	49	50	17	30
25/10	200	50	200	300	80	300	650	90	650	38	40	19	29
60/10	200	60	200	250	80	250	700	90	700	27	30	30	39
15/15	400	60	400	450	100	450	1000	110	1000	50	46	18	32
30/15	300	70	300	350	80	350	900	120	900	35	35	20	32
65/15	220	80	220	250	90	250	850	130	850	25	25	39	39
25/25	400	60	400	500	70	500	1400	100	1400	42	35	23	36
45/25	400	70	400	450	80	450	1100	120	1100	31	28	27	39
80/25	250	80	250	350	90	350	800	130	800	21	21	31	40
35/30	500	70	500	550	80	550	1200	120	1200	38	31	26	37
55/30	350	60	350	450	90	450	800	130	1300	29	26	29	40
95/30	300	90	300	350	120	350	900	150	900	18	18	31	40
45/50	600	80	600	700	100	700	1600	130	2000	32	29	27	39
65/50	500	80	500	600	90	600	1100	140	1700	24	18	28	39
105/50	400	90	400	450	100	450	800	140	1300	17	14	31	39
60/100	700	70	700	900	80	900	2000	130	2500	28	15	31	43
90/100	700	100	700	900	120	900	1300	140	2300	17	9	28	39
140/100	600	120	600	650	140	650	1100	150	1700	12	10	31	43
80/250	1300	130	1300	1700	150	2400	2500	180	4000	21	7	32	43

(where, SMR is the start of the working range, MMR is the middle of the working range, EMR is the end of the working range, MR is the working range)

1.1.2. Configuration settings

The nature of the sensor is determined by its configuration parameters, the change of which is made only by transmitting commands through the serial port RS232 or RS485.

Limited accumulation time: the intensity of reflected radiation coming into the sensor depends on the surface properties of the controlled object, so the laser radiation power and the accumulation time of the radiation which falls on the CMOS ruler, are automatically adjusted to obtain the optimum signal and achieve maximum measurement accuracy. The “limit accumulation time” parameter specifies the maximum allowable accumulation time of the ruler. If the intensity of the radiation received by the sensor is so low, that during accumulation, equal to the time limit, there is no result, sensor transmits a zero value.

Note №1 The frequency of updating of the result depends on the magnitude of accumulation time of the receiving ruler. The maximum frequency (9.4 kHz) is reached for the accumulation time of 106 mcs (minimum accumulation time is 3 mcs). When the accumulation time exceeds over 106 mcs, the refresh rate of the result decreases proportionally.

Increasing this parameter extends control capabilities weakly reflective (diffuse component) surfaces , however, it reduces the refresh rate of the measurement result and increases the impact of the external illumination (background) on measurement accuracy. The maximum accumulation time is 3200 mcs.

Reducing this parameter increases the resultant refresh rate of the result, but may reduce measurement accuracy.

1.1.3. Setting up a sensor connection

When the program starts, a window appears (Fig. 3):

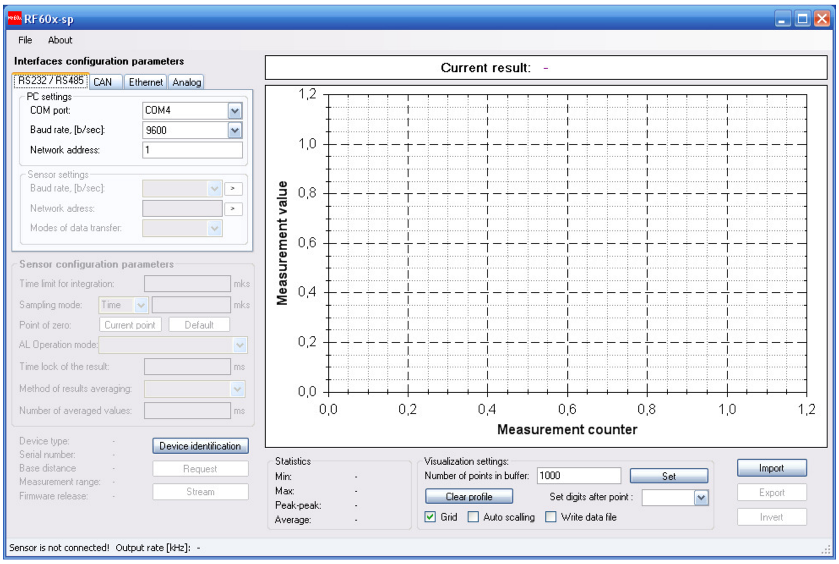

Figure 3. The rf60x-sp application window

To establish a connection on RS232 / RS485 interfaces, it is necessary in RS232 / RS485 tabs of PC settings panel choose following Interface configuration parameters:

- Select the COM port to which the sensor is connected (a virtual port if the sensor is connected via a USB adapter).

- Select Baud rate at which the sensor operates.
- If necessary, select the sensor network address.
- Press the button Device identification.

If the set parameters match the parameters of the interface of a sensor, the program will identify the sensor, read it and display it. Configuration parameters (fig. 4).

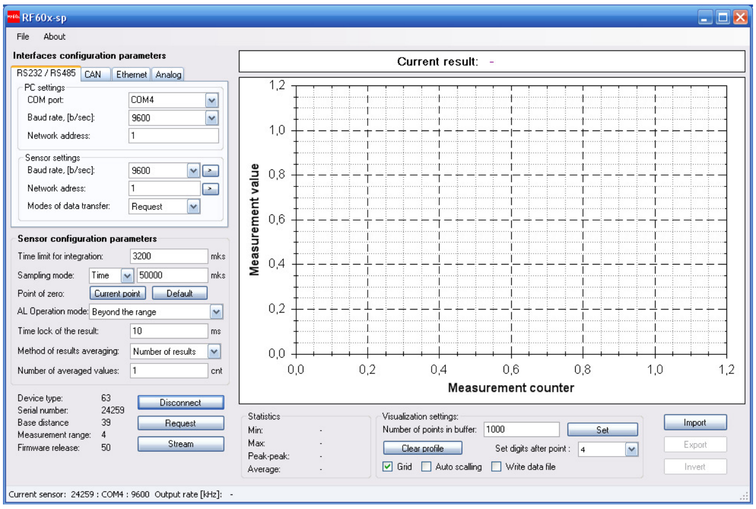

Figure 4. Working interface after successful identification

If no connection is made, a message is prompted to search for the sensor automatically (fig. 5):

- In the Baud rate line, set the transmission speed search range
- Set the net address search range in the Net address row.
- Click the Search button.

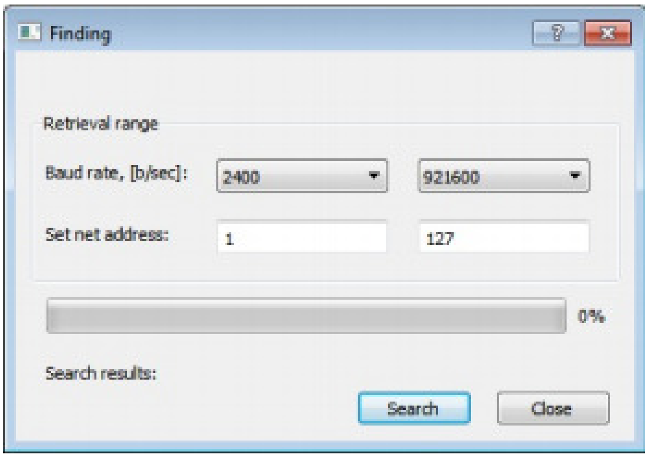

Figure 5. Automatic sensor search window

The program will automatically search for the sensor by searching through the possible speeds, network addresses and COM ports of the PC.
After successful identification, we check the efficiency of the sensor:

- Set the object in the area of the sensor operating range.
- Pressing the Request button displays (Current result) on the display panel of single measurement result.
- Pressing the Stream button puts the sensor into the data stream mode (fig. 6).
- Moving the object, we observe a change in readings (fig. 7).
- The status bar at the bottom of the window displays the current baud rate and data recovery rate.

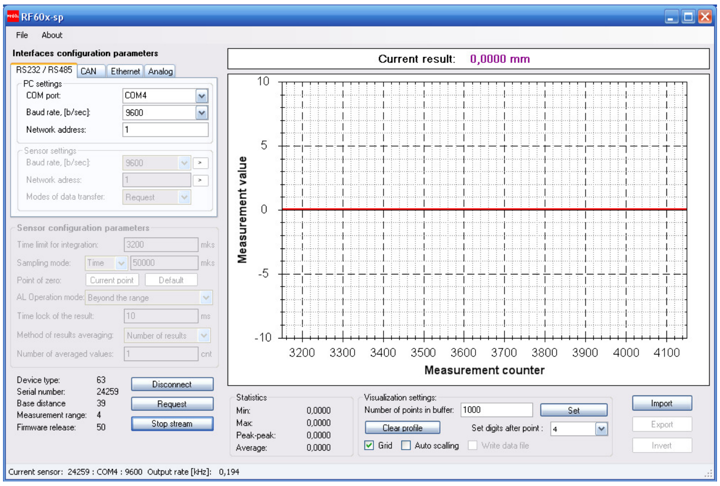

Figure 6. Working window after pressing the Stream button

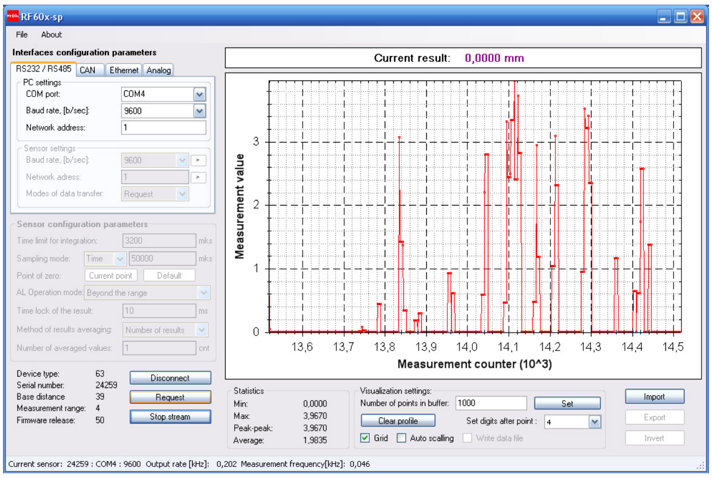

Figure 7. Changes in metrics during an object movement

Pressing the Stop stream button stops the data transmission.

1.1.4. Experimental part

The operation of the triangulation vibration sensor was tested before the experiment at different frequencies over a period of time.

Figure 8 presents the test dependence of the operation of the triangulation vibration sensor when setting up the following settings for a personal computer (PC):

Data transfer speed (interface RS232 or RS485)	9600 bd/s
COM-port	Fourth port
Network address	1
Disconnect button	Disconnect from sensor
Request button	Request a single measurement result
Stop stream button	Stop data transfer
Import button	Import data
Export button	Download data

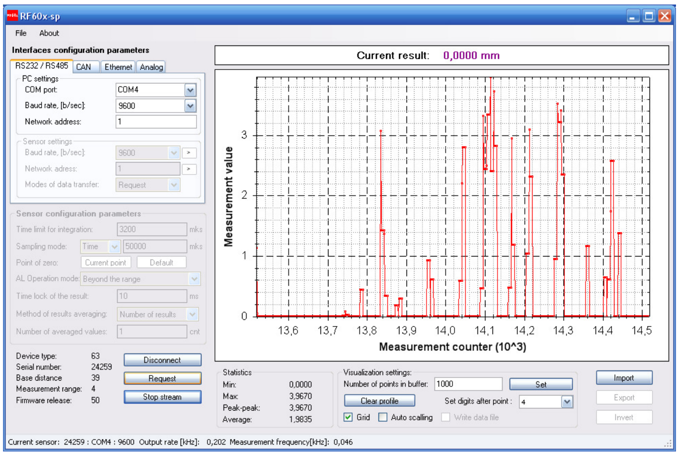

Figure 8. The relative dependence of the reflection of the laser signal with a wavelength of 660 nm at pulse frequencies from 0,046 kHz до 0,202 kHz on a period of time from 13,5s to 14,5 s.

Three samples were used to test the optimal sensor modes: clear glass and specimens with a certain set of spattered elements.

On Fig. 9-10. the dependencies that we achieved as a result of the sensor's operation are presented. The minimum and maximum power and detection periods of these signals (in seconds), shown in the table 2.

Table 2. Experimental measurement results

№	Sample	Pout, min	Pout, max	Period, sec.
1	Clear	2,6282	3,1966	5
2	B-1, glass №10	1,2066	1,4475	3,4
3	Pr prosvita 500-950 nm	0,991	1,4172	6,5

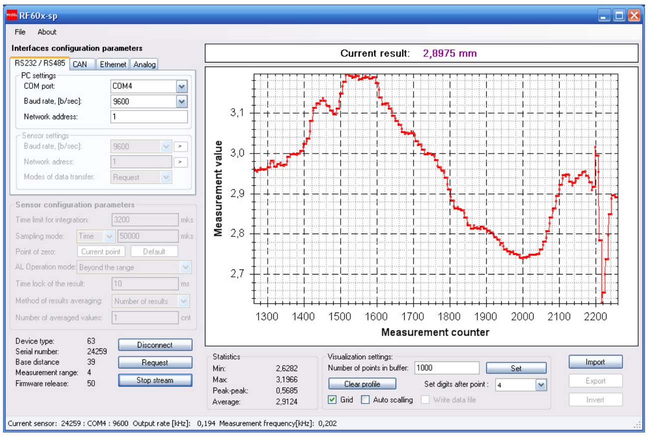

Figure 9. Measurement results of sample № 1

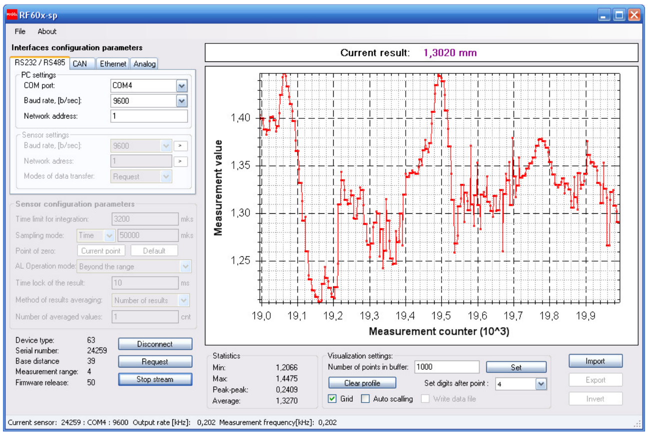

Figure 10. Measurement results of sample № 2

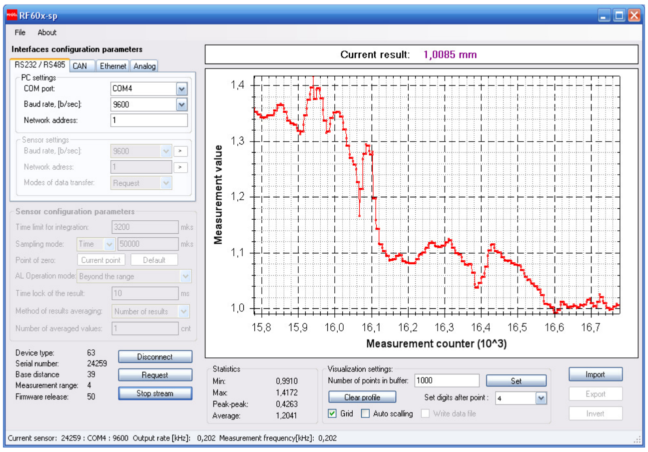

Figure 11. Measurement results of sample № 3

Based on the obtained data, we can say that the best characteristics achieved at frequency of 0,202 kHz and on the period from 3 s. to 6 s.

2. Conclusion

1. Analyzing the operating principles of laser acoustic intelligence systems and passive methods of protection from reading of an acoustic information we can say that use of different types of films (spattered or glued to the glass) is relevant in this area.
2. The method of work with laser triangulation vibration sensors was described.
3. The vibration sensor was configured and an interface for working with spattered samples for passive protection was optimized. Based on the obtained data, we can say that the best characteristics are obtained at frequency of 0,202 kHz and on the period from 3 s. to 6 s.

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