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Passive system of radiovision of a millimetric range

WIRELESS COMMUNICATION SYSTEMS AND SENSOR TECHNOLOGIES

ABSTRACT

From physics it is known, that the more energy which the object radiates, the less energy which it reflects and on the contrary. People are naturally very issue in a millimetric range and consequently reflect very much a small amount of energy of millimetric waves. Metals, on the other hand, are very reflective and consequently reflect the most part of energy of millimetric waves. As the environment usually is colder, than the human body, very reflective objects seem more cool, than human flesh and consequently can be found out on millimetric images. As millimetric waves are capable to pass through the majority of materials of clothes these reflective objects can be found out, even when they are latent under clothes.

Quality of millimetric images improves, when contrast between displayed objects increases. That is the more coldly the environment, the is better the millimetric image. On open air due to the cold sky rather high contrast is provided. In the closed premises contrast is small also the means of detection used on open air here to apply it is impossible [1]. In this case it is necessary to search for other ways of improvement of millimetric images. It is possible to use artificial refrigerating chambers where researched objects are located. Other way is use of cryogenic cooling. Thus those units of the receiver which have the greatest noise temperature are cooled. It allows to raise the general sensitivity and as consequence to register small contrasts between displayed objects.

1. PASSIVE SYSTEM OF RADIOVISION OF A MILLIMETRIC RANGE

As the reception aerial of radiometer lattice which allows to carry out the review of surrounding space is used, to define a direction on a source of radiation and quickly to change a direction of the maximal reception, to work with several objects. Detection of the latent objects with use of the lattices working in a millimetric range of lengths of waves, is a perspective direction of creation of systems of radiovision in places of the big congestion of people that allows to raise potential of systems of detection essentially.

As a result of research of various circuits of construction of system the following structure of system (figure 1) has been developed.

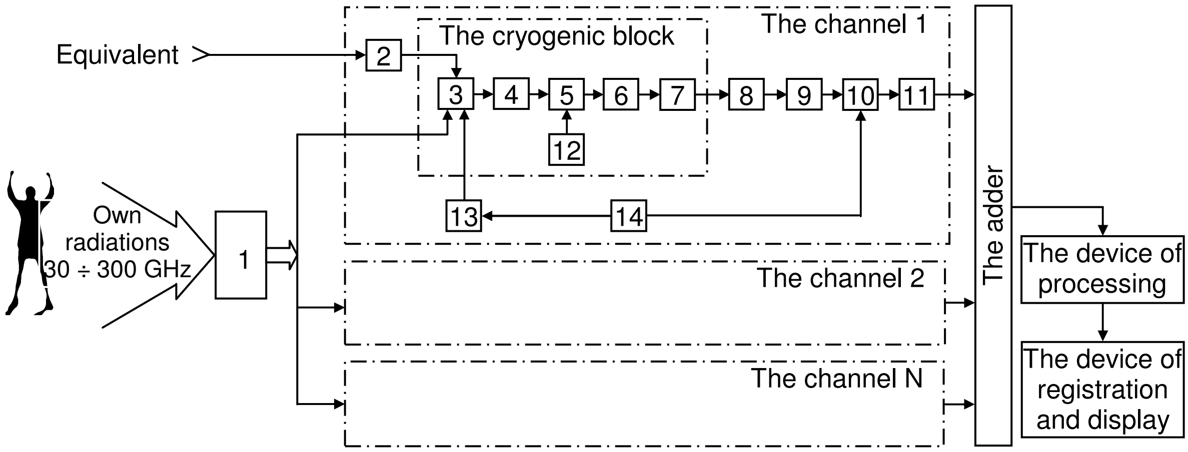

Figure 1: The block diagram of system: 1 – the phase array, 2 – the attenuator, 3 – the switch with magnetic memory, 4 – the amplifier of high frequency, 5 – the amalgamator, 6 – the amplifier of intermediate frequency, 7 – the phase shifter, 8 – the detector, 9 - the amplifier of low frequency, 10 – the synchronous detector, 11 – the filter of low frequency, 12 – the oscillator, 13 – the generator of pulses of the switch with magnetic memory, 14 – the generator of frequency of modulation

Radiothermal radiation is accepted from surrounding space with the help of the reception aerial - the phased array. Further the accepted signal acts on multichannel radiometer modulation type with superheterodyne the receiver in which as a result of action of phase shifters there is a change of distribution of phases of waves in channels on whom energy is brought to the adder. Further the signal from an output of the adder acts on the device after detector processings and the device of registration and display. The device of registration registers change of an electromagnetic field on a surface of object.

For increase of sensitivity the receiver the idea of complex cooling of entrance reception pathes, including the phase shifter, with the help of microcryogenic systems of a nitric level of cooling is realized.

On an output of radiometer there is a mix from a signal and own noise of the receiver. It is known, that a constant component of a current on an output of the radiometer, caused by own noise, cannot be completely compensated on an output owing to its fluctuations which are caused by variations of factor of amplification of radiometer. Fluctuations of factor of amplification of the receiver develop of fluctuations of amplification of separate cascades and are caused by instability of amplification. Instability of amplification is defined by instability of power supplies, temperatures of elements and other similar factors. In modulation radiometer indemnification which is watching fluctuations of amplification, is provided with reception of a compensating current with the help of the pilot - signal missed through all path. As a pilot - signal the equivalent of the aerial is applied. Thus, the radiometer modulation type allows to exclude dependence of sensitivity on fluctuations of factor of amplification.

Except for a useful signal from observable object, on an output of radiometer there is a signal connected to an inequality of temperatures of the aerial and an equivalent. The useful signal should be observed on a background of this parasitic signal which also fluctuates because of instability of factor of amplification of the receiver or instability of one of temperatures. For realization limiting fluctuation sensitivity the parasitic signal should be come to naught, that is to level temperatures of the aerial and an equivalent. The method of introduction of attenuation is applied for this purpose with the help attenuator in a path of an equivalent, that is adjustment of temperature of an equivalent is carried out.

Switching from the aerial on an equivalent is carried out in entrance cryogenic blok by the cooled switch with magnetic memory [2] from which the signal acts on poorly rustling the amplifier of high frequency. The switch with magnetic memory provide the least time of switching among high-speed switches. In them the magnetic stream becomes isolated inside the channel of a wave guide. As a working constant magnetic field in them own residual magnetization of ferrite is used. The second important advantage of such type of the switch - essentially smaller (on one - two order of size) energy of switching of magnetic system. The switch copes from the generator of pulses. Frequency of modulation is provided with the generator of frequency of modulation.

The reception aerial will consist from linear the phased array and two masts on which this ruler of radiators moves. At such design of the reception aerial the diagram of an orientation in a horizontal plane (on an azimuth) moves due to electronic scanning, and in a vertical plane (on a corner of a place) with the help of a power drive which provides movement of the phased array on masts.

The designed parameters of a ruler of radiators are resulted in table 1.

Table 1 - Parameters of a ruler of radiators

The name of parameter	Value of parameter
Frequency f, GHz	37,5
Length of a wave λ, mm	8
Number of radiators on X, pieces	267
The size of a radiator on X, mm	3,6
The size of a radiator on Y, mm	7,2
Distance between radiators on X d, mm	4,8
Width of the diagram of an orientation $\Delta\theta$, degree	0,3
Kind of peak distribution	uniform
Factor of the directed action at $\theta_0 = 0°$, time (dB)	1737,19 (32,40)
Length of a lattice L, m	1,282

Proceeding from requirements to system, the phased array and to a range of frequencies, as managing devices discrete semi-conductor phase shifters are applied, and as system of radiators - the open ends of wave guides or pyramidal megaphones.

Advantages of semi-conductor phase shifters are small dimensions and weight, the big speed of switching, simplicity of managing devices, temperature stability. For reduction of weight, dimensions and semi-conductor phase shifters make increases of stability in strip and microstrip execution that allows to apply printed technology.

Application of the directed radiators what the open ends of wave guides and pyramidal megaphones are, allows to suppress collateral maxima. The number of radiators thus is less than number of radiators which would be required for suppression of collateral maxima if as radiators not directed radiators were used.

The open ends of wave guides radiators have the following advantages:

- simple way of excitation of radiating elements of a having line;
- convenience of interface to phase shifters and dividers of capacity;
- high level of transmitted capacity;
- small losses in a feeding path;
- relative wide passband.

In the given system it is applied consecutive the review of space by the diagram of an orientation of a kind *sinx/x* which turns out with the help of the phased array. The kind of a way of the review is submitted in figure 2.

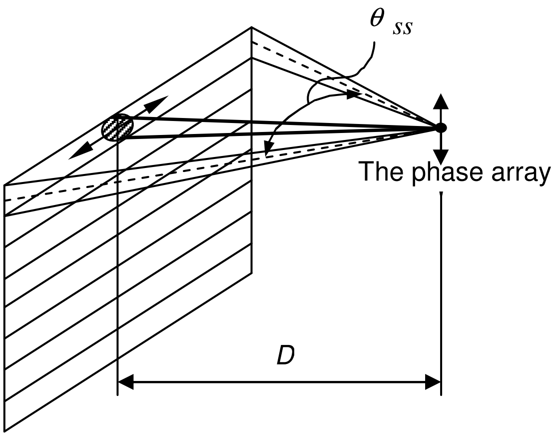

Figure 2: The Way of the review of space:
θ_{ss} – Sector of scanning; *D* – Range up to object of radiation.

The designed parameters of system at application of cryogenic cooling and parameters of system without cooling are tabulated 2.

Table 2 - Parameters of system without cooling and at cooling

Parameter	Without cooling	At cooling
Noise temperature of the receiver $T_{\mathrm{n.r}}$, K	150	45,7
Noise temperature of the aerial $T_{\mathrm{n.a}}$, K	80	22
Noise temperature of system T_{n}, K	230	67,7
Sensitivity of system ΔT, K at $\Delta f = 100$ MHz and τ = 1 s	0,046	0,013
Minimally found out stream of a radio emission $P_{\min}$, Joule /m^2	$1{,}38 \cdot 10^{-22}$	$0{,}3 \cdot 10^{-22}$

Apparently from table 2, at application of cryogenic cooling sensitivity raises and minimally found out stream of a radio emission decreases.

2. CALCULATION OF RANGE OF ACTION OF PASSIVE SYSTEM OF RADIOVISION OF A MILLIMETRIC RANGE

Range of action of system is defined by sensitivity and its resolution.

It is known, that any object radiates electromagnetic energy in a wide range of lengths of waves. If radiation of energy occurs in regular intervals on all directions all energy is distributed on the area of sphere of radius *D* equal $4 \cdot \pi \cdot D^2$. Then, if *D* – distance between object and the receiver (required range of action), C_{ob} – capacity of radiation of object (intensity of radiation), the capacity falling 1 m^2, that is the density of a stream of capacity in area of the reception aerial, is equal

$$D_{\text{sa}} = \frac{C_{\text{ob}}}{4 \cdot \pi \cdot D^2} . \tag{1}$$

Reception aerial – is a barrier absorbing a stream of energy which radiates object. Let the effective area of the aperture of the reception aerial is equal S_{eff}. Then if to neglect losses in the reception aerial capacity of a signal on its output is equal

$$C_{\text{sa}} = D_{\text{sa}} \cdot S_{\text{eff}} = \frac{C_{\text{ob}} \cdot S_{\text{eff}}}{4 \cdot \pi \cdot D^2} . \tag{2}$$

The minimal capacity of a signal on an input of the receiver $C_{\min}$ is equal

$$C_{\min} = \frac{2 \cdot k \cdot \Delta T}{S_{\text{eff}}} . \tag{3}$$

As $C_{\text{sa}} = C_{\min}$, taking into account formulas (3) and (2) it is possible to write down the following equality

$$\frac{C_{\text{ob}} \cdot S_{\text{eff}}}{4 \cdot \pi \cdot D^2} = \frac{2 \cdot k \cdot \Delta T}{S_{\text{eff}}} , \tag{4}$$

whence we shall receive

$$D = \sqrt{\frac{C_{\text{ob}} \cdot S_{\text{eff}}}{4 \cdot \pi \cdot C_{\min}}} = \sqrt{\frac{C_{\text{ob}} \cdot S_{\text{eff}}{}^2}{8 \cdot \pi \cdot k \cdot \Delta T}} . \tag{5}$$

Intensity of radiation of object C_{ob} is expressed through temperature of brightness T_b as follows:

$$C_{ob} = \frac{k \cdot T_b}{2 \cdot \pi \cdot \lambda^2}, \tag{6}$$

where k = 1,38·10^{-23} Joule· K^{-1} - constant; λ - length of a wave, m.

Having substituted the formula (6) in (5) we shall receive, that

$$D = \sqrt{\frac{T_b \cdot S_{eff}^2}{16 \cdot \pi^2 \cdot \Delta T \cdot \lambda^2}}. \tag{7}$$

The formula (7) connects range of system D with parameters of system (sensitivity ΔT and the effective area of the aperture of the reception aerial S_{eff}) and with parameters of object (temperature of brightness T_b). From this formula it is visible, that for increase in range of action it is necessary to raise sensitivity of system (that is to reduce its absolute value) and to increase the effective area of the aperture of the reception aerial.

Sense of range of the action designed under the formula (7) following: if the object is within the limits of range of action the system allows to receive his image. Otherwise sensitivity of system does not suffice for reception of the image of object.

Let's consider, on what sizes ΔT, S_{eff}, T_b depend. For the receiver modulation type sensitivity of system ΔT is under the following formula [3]:

$$\Delta T = \frac{2 \cdot T_n}{\sqrt{\Delta f \cdot \tau}}, \tag{8}$$

where T_n - noise temperature of system, To; Δf - a passband of the amplifier of intermediate frequency, Hz; τ - a constant of time of integration, s.

From the formula (8) it is visible, that at set Δf and τ sensitivity of system depends from noise temperatures of system T_n which can be expressed through factor of noise F_n as follows [3]:

$$T_{\mathrm{n}} = T_0 \cdot \left(F_{\mathrm{n\,time}} - 1 \right) = T_0 \cdot \left(10^{F_{\mathrm{n\,dB}}/10} - 1 \right), \tag{9}$$

where $T_0 = 290\,\mathrm{K}$.

The effective area of the aperture of the reception aerial as which the lattice is applied the phased array is possible to calculate as follows:

$$S_{\mathrm{eff}} = \kappa \cdot L_{\mathrm{x}} \cdot L_{\mathrm{y}}, \tag{10}$$

where κ - operating ratio of a surface; L_{x} - length of the phased array on X, m; L_{y} - length of the phased array on Y, m.

The temperature of brightness is under the following formula:

$$T_{\mathrm{b}} = T_{\mathrm{ob}} \cdot \left(1 - F_{\mathrm{ob}}\right) + T_{\mathrm{bac}} \cdot F_{\mathrm{ob}}, \tag{11}$$

where T_{ob} - true absolute (physical) temperature of researched object; $1 - F_{\mathrm{ob}} = \kappa$ - radiating ability of object; F_{ob} - factor of reflection (on capacity) an electromagnetic wave from a surface of object; T_{bac} - the absolute temperature describing background radiation (for example, the sky), irradiating object.

T_{b} It is measured with the help of the aerial, by movement of the basic petal of the diagram of an orientation of the aerial on object.

Generally T_{b} is the effective temperature of the researched environment average on depth, that is

$$T_{\mathrm{bav}} = \sum_{i=1}^{N} T_{\mathrm{bi}} \Big/ N. \tag{12}$$

For the person with a body temperature T_{ob} = 36 °C = 36 + 273 = 309 K, an environment with temperature T_{bac} = 20 °C = 20 + 273 = 293 K and F_{ob} = 0,5 (it corresponds to factor of reflection from a body of the person in a millimetric wave band) we shall receive, that T_{b} = 301 K.

For a subject of the person taking place on a body, for example a pistol with temperature T_{ob} = 0 °C = 0 + 273 = 273 K, T_{bac} = 20 °C = 20 + 273 = 293 K and F_{ob} = 1 we shall receive, that $T_{\mathrm{b}} = T_{\mathrm{bac}} \cdot F_{\mathrm{ob}}$ = 293 K.

Then under the formula (12) we shall receive, that T_{bav} = (301+293/2 = 297 K. With growth T_{bav} range of action increases.

Let's calculate range of action of system under the formula (7) for two lengths of waves (8 mm and 3 mm) at corresponding to these lengths of waves factors of noise and at various values of number of radiators on X and on Y for linear and flat the phased array. By results of calculation we shall make table 3 and 4 and we shall construct family of dependences of range from length of a wave at various values of factor of noise of the receiver, corresponding to the cooled and not cooled receiver, for linear and flat the phased array of the open ends of wave guides (figure 3).

Table 3. Calculation of range of action of system with linear the phased array from the open ends of wave guides

Parameter	Number of the formula	Value of parameter											
		With cooling						Without cooling					
		λ = 8 mm		λ = 3 mm				λ = 8 mm		λ = 3 mm			
F_n, dB	-	1		3	6	3	6	2		4,7	9	4,7	9
T_n, K at $T_0 = 290$ K	9	75		289	865	289	865	170		566	2014	566	2014
ΔT, K at Δf =100 MHz and τ = 1 s	8	0,015		0,058	0,173	0,058	0,173	0,034		0,113	0,403	0,113	0,403
n_x, pieces	-	267	16	267		16		267	16	267		16	
n_y, pieces	-	1											
l_x, *m*	-	$3{,}6 \cdot 10^{-3}$		$1{,}2 \cdot 10^{-3}$				$3{,}6 \cdot 10^{-3}$		$1{,}2 \cdot 10^{-3}$			
l_y, *m*	-	$7{,}2 \cdot 10^{-3}$		$2{,}4 \cdot 10^{-3}$				$7{,}2 \cdot 10^{-3}$		$2{,}4 \cdot 10^{-3}$			
$L_x = n_x \cdot l_x$, m	-	0,961	0,058	0,32		0,019		0,961	0,058	0,32		0,019	
$L_y = n_y \cdot l_y$, m	-	$7{,}2 \cdot 10^{-3}$		$2{,}4 \cdot 10^{-3}$				$7{,}2 \cdot 10^{-3}$		$2{,}4 \cdot 10^{-3}$			
S_{eff}, m^2 at κ = 0,4	10	$2{,}77 \cdot 10^{-3}$	$1{,}66 \cdot 10^{-4}$	$3{,}08 \cdot 10^{-4}$		$1{,}84 \cdot 10^{-5}$		$2{,}77 \cdot 10^{-3}$	$1{,}66 \cdot 10^{-4}$	$3{,}08 \cdot 10^{-4}$		$1{,}84 \cdot 10^{-5}$	
T_{bav}, K	12	297											
D, m	7	3,872	0,232	0,585	0,338	0,035	0,02	2,577	0,154	0,418	0,222	0,025	0,013

Table 4. Calculation of range of action of system with flat the phased array 16x16 and 16x5 from the open ends of wave guides

Parameter	Number of the formula	Value of parameter											
		With cooling						Without cooling					
		$\lambda = 8$ mm		$\lambda = 3$ mm				$\lambda = 8$ mm		$\lambda = 3$ mm			
F_n, dB	-	1		3	6	3	6	2		4,7	9	4,7	9
T_n, K at $T_0 = 290$ K	9	75		289	865	289	865	170		566	2014	566	2014
ΔT, K at Δf =100 MHz and $\tau = 1$ s	8	0,015		0,058	0,173	0,058	0,173	0,034		0,113	0,403	0,113	0,403
$n_x \times n_y$, pieces	-	16×16	16×5	16×16		16×5		16×16	16×5	16×16		16×5	
l_x, m	-	$3{,}6\cdot10^{-3}$		$1{,}2\cdot10^{-3}$				$3{,}6\cdot10^{-3}$		$1{,}2\cdot10^{-3}$			
l_y, m	-	$7{,}2\cdot10^{-3}$		$2{,}4\cdot10^{-3}$				$7{,}2\cdot10^{-3}$		$2{,}4\cdot10^{-3}$			
$L_x = n_x \cdot l_x$, m	-	0,058		0,019				0,058		0,019			
$L_y = n_y \cdot l_y$, m	-	0,115	0,036	0,038		0,012		0,115	0,036	0,038		0,012	
S_{eff}, m^2 at $\kappa = 0{,}4$	10	$2{,}65\cdot10^{-3}$	$8{,}29\cdot10^{-4}$	$2{,}95\cdot10^{-4}$		$9{,}22\cdot10^{-5}$		$2{,}65\cdot10^{-3}$	$8{,}29\cdot10^{-4}$	$2{,}95\cdot10^{-4}$		$9{,}22\cdot10^{-5}$	
T_{bav}, K	12	297											
D, m	7	3,713	1,16	0,561	0,324	0,175	0,101	2,47	0,772	0,401	0,212	0,125	0,066

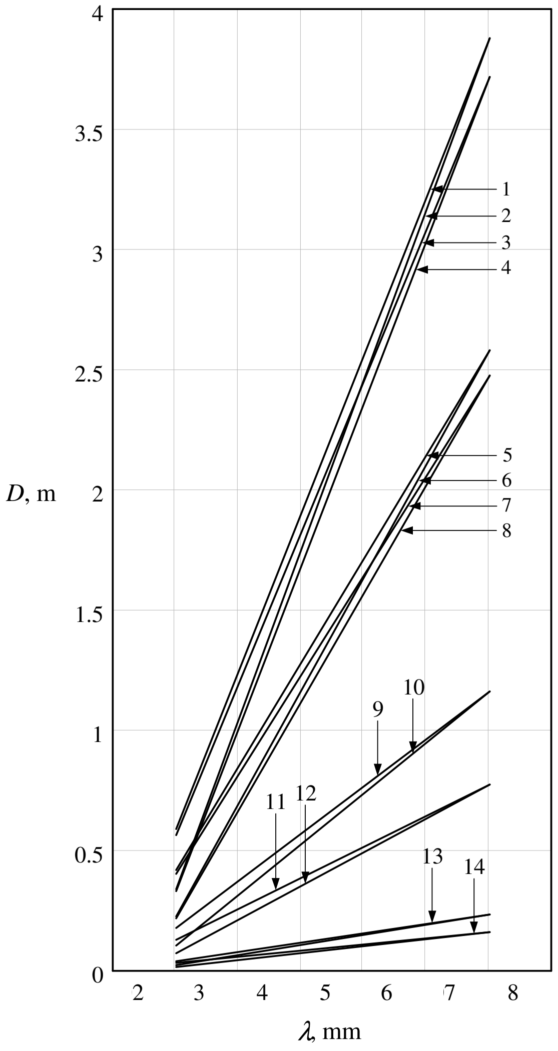

Figure 3: Family of dependences of range from length of a wave for linear and flat the phased array from the open ends of wave guides:

1 – $n_x = 267$, $n_y = 1$, system with cooling, F_n (3mm) = 3 dB, F_n (8mm) = 1 dB;

2 – $n_x = 267$, $n_y = 1$, system with cooling, F_n (3mm) = 6 dB, F_n (8mm) = 1 dB;

3 – $n_x = 16$, $n_y = 16$, system with cooling, F_n (3mm) = 3 dB, F_n (8mm) = 1 dB;

4 – $n_x = 16$, $n_y = 16$, system with cooling, F_n (3mm) = 6 dB, F_n (8mm) = 1 dB;

5 – $n_x = 267$, $n_y = 1$, system without cooling, F_n (3mm) = 4,7 dB, F_n (8mm) = 2 dB;

6 – $n_x = 267$, $n_y = 1$, system without cooling, F_n (3mm) = 9 dB, F_n (8mm) = 2 dB;

7 – $n_x = 16$, $n_y = 16$, system without cooling, F_n (3mm) = 4,7 dB, F_n (8mm) = 2 dB;

8 – $n_x = 16$, $n_y = 16$, system without cooling, F_n (3mm) = 9 dB, F_n (8mm) = 2 dB;

9 – $n_x = 16$, $n_y = 5$, system with cooling, F_n (3mm) = 3 dB, F_n (8mm) = 1 dB;

10 – $n_x = 16$, $n_y = 5$, system with cooling, F_n (3mm) = 6 dB, F_n (8mm) = 1 dB;

11 – $n_x = 16$, $n_y = 5$, system without cooling, F_n (3mm) = 4,7 dB, F_n (8mm) = 2 dB;

12 – $n_x = 16$, $n_y = 5$, system without cooling, F_n (3mm) = 9 dB, F_n (8mm) = 2 dB;

13 – $n_x = 16$, $n_y = 1$, system with cooling; 14 – $n_x = 16$, $n_y = 1$, system without cooling.

Analyzing dependences in figure 3 it is possible to draw the following conclusions:

- at application of the open ends of wave guides as radiating system range with reduction of length of a wave decreases; it occurs because of increase in factor of noise of the receiver and reduction of the sizes of a wave guide;

- on $\lambda = 8$ mm range strongly depends on quantity of radiators and factor of noise of the receiver;

- on $\lambda = 3$ mm range has essentially decreased and poorly depends on quantity of radiators and factor of noise of the receiver because of deterioration of sensitivity and reduction of the effective area of the aperture of the aerial;

- on $\lambda = 8$ mm linear the phased array with 267 radiators range, as flat the phased array in the size 16×16 about 3,7 m at cooling and has approximately harder 2,5 m without cooling.

Let's lead calculation of range under the formula (7) and we shall make tables 5 both 6 similar to tables 3 and 4 at application as system of radiators of pyramidal megaphones at which the sizes do not depend on length of a wave. According to tables 5 and 6 we shall construct family of dependences of range from length of a wave at various values of factor of noise of the receiver, corresponding to the cooled and not cooled receiver, for linear and flat the phased array of pyramidal megaphones (figure 4).

Table 5. Calculation of range of action of system with linear the phased array from pyramidal megaphones

Parameter	Number of the formula	Value of parameter											
		With cooling						With cooling					
		λ = 8 mm		λ = 3 mm				λ = 8 mm		λ = 3 mm			
F_n, dB	-	1		3	6	3	6	2		4,7	9	4,7	9
T_n, K at $T_0 = 290$ K	9	75		289	865	289	865	170		566	2014	566	2014
ΔT, K at Δf =100 MHz and τ = 1 s	8	0,015		0,058	0,173	0,058	0,173	0,034		0,113	0,403	0,113	0,403
n_x, pieces	-	267	16	267		16		267	16	267		16	
n_y, pieces	-	1											
l_x, m	-	$3{,}6 \cdot 10^{-3}$											
l_y, m	-	$7{,}2 \cdot 10^{-3}$											
$L_x = n_x \cdot l_x$, m	-	0,961	0,058	0,961		0,058		0,961	0,058	0,961		0,058	
$L_y = n_y \cdot l_y$, m	-	$7{,}2 \cdot 10^{-3}$											
S_{eff}, m^2 at $\kappa = 0{,}4$	10	$2{,}77 \cdot 10^{-3}$	$1{,}66 \cdot 10^{-4}$	$2{,}77 \cdot 10^{-3}$		$1{,}66 \cdot 10^{-4}$		$2{,}77 \cdot 10^{-3}$	$1{,}66 \cdot 10^{-4}$	$2{,}77 \cdot 10^{-3}$		$1{,}66 \cdot 10^{-4}$	
T_{bav}, K	12	297											
D, m	7	3,872	0,232	5,267	3,043	0,316	0,182	2,577	0,154	3,762	1,994	0,225	0,119

Table 6. Calculation of range of action of system with flat the phased array 16x16 and 16x5 from pyramidal megaphones

Parameter	Number of the formula	Value of parameter											
		With cooling						With cooling					
		λ = 8 mm		λ = 3 mm				λ = 8 mm		λ = 3 mm			
F_n, dB	-	1		3	6	3	6	2		4,7	9	4,7	9
T_n, K at $T_0 = 290\,K$	9	75		289	865	289	865	170		566	2014	566	2014
ΔT, K at Δf =100 MHz and τ = 1 s	8	0,015		0,058	0,173	0,058	0,173	0,034		0,113	0,403	0,113	0,403
$n_x \times n_y$, pieces	-	16×16	16×5	16×16		16×5		16×16	16×5	16×16		16×5	
l_x, *m*	-	$3{,}6 \cdot 10^{-3}$											
l_y, *m*	-	$7{,}2 \cdot 10^{-3}$											
$L_x = n_x \cdot l_x$, m	-	0,058											
$L_y = n_y \cdot l_y$, m	-	0,115	0,036	0,115		0,036		0,115	0,036	0,115		0,036	
S_{eff}, m^2 at κ = 0,4	10	$2{,}65 \cdot 10^{-3}$	$8{,}29 \cdot 10^{-4}$	$2{,}65 \cdot 10^{-3}$		$8{,}29 \cdot 10^{-4}$		$2{,}65 \cdot 10^{-3}$	$8{,}29 \cdot 10^{-4}$	$2{,}65 \cdot 10^{-3}$		$8{,}29 \cdot 10^{-4}$	
T_{bav}, K	12	297											
D, m	7	3,713	1,16	5,05	2,918	1,578	0,912	2,47	0,772	3,607	1,912	1,127	0,597

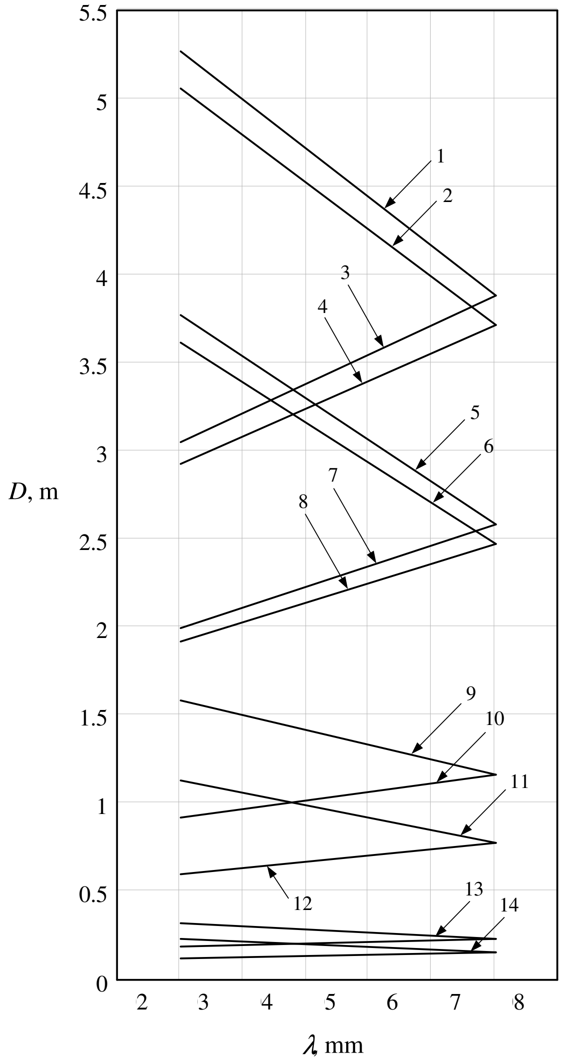

Figure 4: Family of dependences of range from length of a wave for linear and flat the phased array from pyramidal megaphones:

1 – $n_x = 267$, $n_y = 1$, system with cooling, F_n (3мм) = 3 dB, F_n (8мм) = 1 dB;

2 – $n_x = 16$, $n_y = 16$, system with cooling, F_n (3мм) = 3 dB, F_n (8мм) = 1 dB;

3 – $n_x = 267$, $n_y = 1$, system with cooling, F_n (3мм) = 6 dB, F_n (8мм) = 1 dB;

4 – $n_x = 16$, $n_y = 16$, system with cooling, F_n (3мм) = 6 dB, F_n (8мм) = 1 dB;

5 – $n_x = 267$, $n_y = 1$, system without cooling, F_n (3мм) = 4,7 dB, F_n (8мм) = 2 dB;

6 – $n_x = 16$, $n_y = 16$, system without cooling, F_n (3мм) = 4,7 dB, F_n (8мм) = 2 dB;

7 – $n_x = 267$, $n_y = 1$, system without cooling, F_n (3мм) = 9 dB, F_n (8мм) = 2 dB;

8 – $n_x = 16$, $n_y = 16$, system without cooling, F_n (3мм) = 9 dB, F_n (8мм) = 2 dB;

9 – $n_x = 16$, $n_y = 5$, system with cooling, F_n (3мм) = 3 dB, F_n (8мм) = 1 dB;

10 – $n_x = 16$, $n_y = 5$, system with cooling, F_n (3мм) = 6 dB, F_n (8мм) = 1 dB;

11 – $n_x = 16$, $n_y = 5$, system without cooling, F_n (3мм) = 4,7 dB, F_n (8мм) = 2 dB;

12 – $n_x = 16$, $n_y = 5$, system without cooling, F_n (3мм) = 9 dB, F_n (8мм) = 2 dB;

13 – $n_x = 16$, $n_y = 1$, system with cooling; 14 – $n_x = 16$, $n_y = 1$, system without cooling.

Analyzing dependences in figure 4 it is possible to draw the following conclusions:

- at application of pyramidal megaphones as radiating system range with reduction of length of a wave increases; however it is fair at factor of noise of the receiver on length of a wave of 3 mm 3 dB at cooling and 4,7 dB without cooling; at increase in factor of noise up to 6 dB at cooling and 9 dB without cooling range with reduction of length of a wave decreases; it is the fact imposes the certain requirements on noise parameters of reception system;

- on λ = 8 mm and on λ = 3 mm range equally depends on quantity of radiators and factor of noise of the receiver;

- on λ = 8 mm with cooling and on λ = 3 mm without cooling (F_n = 4,7 dB) linear the phased array with 267 radiators and flat the phased array in the size 16×16 have approximately identical range about 3,7 m;

- on λ = 8 mm with cooling and on λ = 3 mm without cooling (F_n = 4,7 dB) flat the phased array in the size 16×5 have approximately identical range 1 m.

According to tables 3 - 6 it is possible to construct dependence of range on factor of noise of the receiver linear the phased array with 267 radiators and flat the phased array of the sizes 16×16 at various lengths of waves and types of radiators (figure 5).

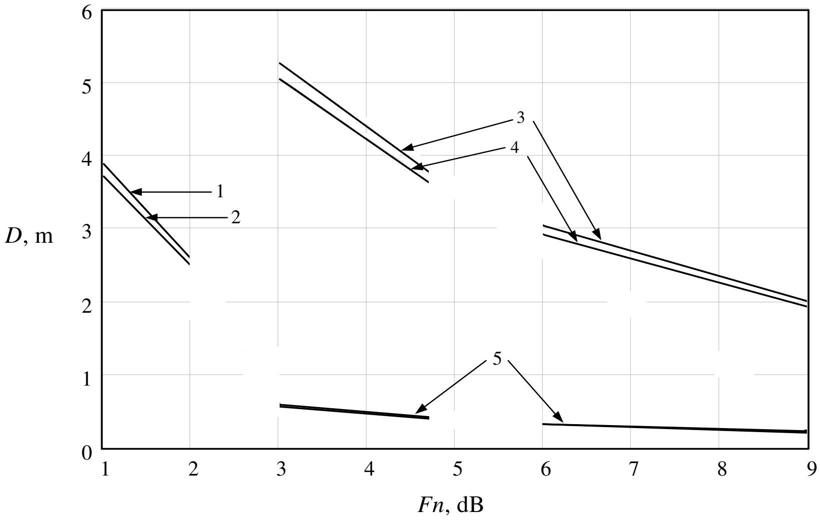

Figure 5: Dependence of range on factor of noise of the receiver linear the phased array with 267 radiators and flat the phased array of the sizes 16×16:

1 – λ = 8 mm, n_x =267, n_y = 1, the open ends of wave guides and pyramidal megaphones;

2 – λ = 8 mm, n_x =16, n_y = 16, the open ends of wave guides and pyramidal megaphones;

3 – λ = 3 mm, n_x =267, n_y = 1, pyramidal megaphones;

4 – λ = 3 mm, n_x =16, n_y = 16, pyramidal megaphones;

5 – λ = 3 mm, n_x =267, n_y = 1 (n_x =16, n_y = 16), the open ends of wave guides.

From figure 5 the following is visible:

- both at length of a wave of 8 mm, and at length of a wave of 3 mm with reduction of factor of noise range increases;

- at length of a wave of 8 mm range does not depend on type of a radiator;

- at length of a wave of a lattice of 3 mm with pyramidal megaphones have stronger dependence of range on factor of noise, than a lattice with the open ends of wave guides; it allows to speak about more effective cooling system with pyramidal megaphones, than systems with the open ends of wave guides.

3. CONCLUSION

At length of a wave of 8 mm range of action increases only at cooling system; at replacement the open ends of wave guides on pyramidal megaphones range of action does not change, as the effective area of the aperture of the aerial is kept.

At length of a wave of 3 mm replacement the open ends of wave guides pyramidal megaphones allows to receive the big range of action as pyramidal megaphones on length of a wave of 3 mm have harder the area, as on length of a wave of 8 mm. For this reason cooling of system with pyramidal megaphones more effectively, than cooling of system with the open ends of wave guides.

Range of action of passive system of radiovision influences both structure of system, and on structure of the aerial, and also necessity of cooling and type of a radiator. So for range of action of 1 m it is possible to make the following structures of system: 1) length of a wave - 8 mm, with cooling (F_n = 1 dB), the phased array in the size 16×5 the open ends of wave guides or pyramidal megaphones; 2) length of a wave - 3 mm, without cooling (F_n = 4,7 dB), the phased array in the size 16×5 pyramidal megaphones.

For range of action of 3 m it is possible to make only the following structure of system: length of a wave - 3 mm, with cooling (F_n = 6 dB), the phased array in the size 267×1 or 16×16 pyramidal megaphones.

For range of action of 4 m it is possible to make the following structures of system: 1) length of a wave - 8 mm, with cooling (F_n = 1 dB), the phased array in the size 267×1 or 16×16 the open ends of wave guides or pyramidal megaphones; 2) length of a wave - 3 mm, without cooling (F_n = 4,7 dB), the phased array in the size 267×1 or

16×16 pyramidal megaphones.

For range of action of 5 m it is possible to make only the following structure of system: length of a wave - 3 mm, with cooling (F_n = 3 dB), the phased array in the size 267×1 or 16×16 pyramidal megaphones.

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