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THE PROBABILITY OF A SIGNAL PASSING THE SHORT-WAVE RANGE IN A P--ETC(U)
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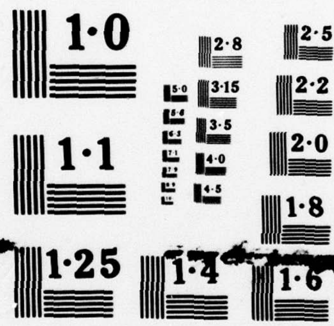
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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

THE PROBABILITY OF A SIGNAL PASSING THE SHORT-WAVE RANGE IN A PATH OF AVERAGE LENGTH

by

P. M. Gatal'skiy

FOREIGN TECHNOLOGY DIVISION

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А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

THE PROBABILITY OF A SIGNAL PASSING
THE SHORT-WAVE RANGE IN A PATH OF AVERAGE LENGTH

P. M. Gatal'skiy

This work describes the results derived from an analysis of a short-wave signal passing in a middle-latitude path - Moscow-Alma-Ata. The receiving equipment is at Alam-Ata and consists of an antenna of the type VGD 8/30 oriented along the azimuth to the transmission point, radio receiver R-250M, and an automatic recorder. The accumulated experimental material has enabled us to carry out an analysis of radio waves passing the short-wave range in the given path. The transmitter operated a certain period of time at each of the indicated frequencies. The recording of the radio-signal envelope lasted 4 min at one frequency, after which, the transmitter was shut off at the given frequency. When in the course of this recording the level of recording of the envelope decreased sharply, the result was that the envelope of the given frequency was recorded; when, under the same conditions, there was no sharp decrease in the level of the envelope, the envelope of interference of the jamming station, which prevents the isolation of a useful signal, was recorded. The number of cases when the envelope of a useful signal was recorded (which corresponded to the passage of frequency) was determined by the number n, the number of cases when the envelope of the interference was recorded was designated by the number n', and the cases when the interferences and the signal were absent - by the number n".

The period analyzed includes 1967-1970, which corresponds to approximately 5,000 measurements. The number of measurements is designated by the number N. The following probabilities were determined for the evaluation of the passage of the radio waves: passage of frequencies, presence of interferences, and the absence of both the useful signal and the interference, i.e., a case when frequencies do not pass due to the decrease in the maximum frequencies used in the F2 region. The probability was determined using the formula $P=\frac{n}{N}\cdot 100\%$

Analysis of the experimental results

Figure 1, a shows the passage probability distribution for ten frequencies in the period of 1967-1970. We can see from the distribution, that for period analyzed, the better passage of radio waves of the short-wave range was observed at mid-frequencies: 12000 - 15000 kHz. At these frequencies the probability is equal to 55-75%. At frequencies below 12000 and above 15000 kHz, the probability of passage is somewhat lower, and the low-frequency portion of the SW range does not pass as well as the high-frequency part. Thus, for example, at the frequency of 4560 kHz the probability fluctuates between 5 and 12% from 1967 to 1970, at the time when for the frequency of 23060 kHz, the probability changes from 35 to 40%, i. e., the passage of the frequency at 23060 kHz is 30% higher on the average, than at 4560 kHz. We should also note that the probability of transmission of all the frequencies examined decreases from 1967 towards 1970. Further, it is evident from Fig. 1, a that a sharp decrease is observed in the probability at the frequencies of 16000 and 18000 kHz, these frequencies did not pass as well as the 21000 and 23000 kHz. A similar phenomenon is noted also at the frequencies of 8000-10000 kHz. To explain the reasons for the sharp decrease in the probability of passage of the frequencies in the high-frequency and low-frequency segments of the range, we examined the LUF and MUF regions of the F2 for this period of time. The data for the LUF and MUF were obtained from the ionosphere observations conducted at the Novokazalinsk station located approximately at the mid-point of the path. As shown by the ionosphere situation, the distributions of the monthly median values of the LUF and MUF during a 24-hour period do not have sharp peaks, consequently, the distributions of the frequency passage values should bear a monotonic nature, if the passage of the frequencies depends only on LUF and MUF. In actuality, however, a sharp decrease in the probability of passage is observed at certain intermediate frequencies of the SW range and, as was later confirmed, the reasons are hidden in the presence of interferences which prevent the measurement of the field strength of the useful signal. Fig. 1, b shows

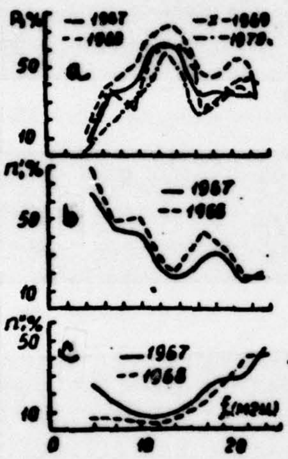

Fig. 1. Passage probability distribution of frequencies for the period of 1967-1970 (a); probability distribution of interferences (b); distribution of cases when frequencies were not transmitted due to dominance of the working frequency over MUF (c).

the yearly trends (1967, 1968) of the observation cases of interferences. These curves are in an antiphase with the curves shown in Fig. 1, a and, what is significant, there is a rigid correlation between the presence of the interferences and the number of passages of the frequencies. Fig. 1, c reproduces the yearly trend of the nonpassages of radio frequencies due to the dominance of the working frequencies over the MUF. It is evident that the curves have an almost monotonic nature, consequently, a sharp decrease in the probability of passage of the frequencies is caused by the presence of interferences at the working frequencies. The contribution of the interferences and MUF to the nonpassage of frequencies in the mid-portion and the high-frequency part of the working frequency range (11000–23000 kHz) is presented in the table.

As seen from the table, in all cases, righ up to the frequency of 20925 kHz, the values of n' prevail over the values of n". With

The number of cases in % of the presenee of interferences,
absence of interferences and a useful signal

a) Год	b) Число случаев, %	c) Частота						
		11620	13770	14810	16175	18190	20037	22060
1967	n''	6	8	13	23	27	29	44
	n'	20	17	20	30	32	27	20
1968	n''	3	7	10	15	22	40	40
	n'	28	22	33	44	36	18	18

Key: a) Year b) Number of cases, % c) Frequency

regard to the low frequencies, 4560, 6955, and 9860 kHz, the number of interferences at these frequencies is considerably larger, than at the medium and high frequncies; in this case, their number grows with a decrease in frequency (Fig. 1, b). Thus, at the frequency of 4560 and 9860 kHz, the probability of presence of the interferences is 65 and 40%, respectively. Further we examined the probability of transmission of frequencies by seasons and for two periods of illumination of the day and night.

Figure 2, a shows the graphs of frequency transmission for 1967 and 1968 for three periods: winter, summer, and equinox. It is evident that there is a seasonal dependence of frequency transmissions, and to be specific, the probability of transmissions increases from winter to summer. (We will designate the increase in brobability of frequency transmissions in terms of ΔP). The value of ΔP is not the same for all frequencies examined. Thus, for the medium frequencies (11000–15000 kHz), ΔP is equal to 26% (1967) and 23% (1968), i. e., the values are commensurate. At the low frequencies of 6955 and 9860 kHz, ΔP is equal to 30 and 20%, respectively (1967), for the same frequencies, ΔP is equal to 12 and 0% in 1968. At high frequencies ΔP=10–15%.

Figure 2, c shows the distribution of probabilities of the frequency transmission during the period of illumination - day and night. It is evident that there is a substantial difference in the frequency passage during the various periods of illumination. The medium and high frequencies pass better during the day. Thus, for the frequencies of 11620 and 23060 kHz (excluding the 16190 kHz frequency) the probability is at least 50% and at individual frequencies - 80%. In the low-frequency region of the SW range an increase in probability is characteristic with an increase in frequencies: for the 4560 kHz frequency P=5% and for the 9860 kHz frequency P= 35%, and the passage of frequencies during the day depends strongly on the presence of interferences whose distribution is shown in Fig. 2, d.

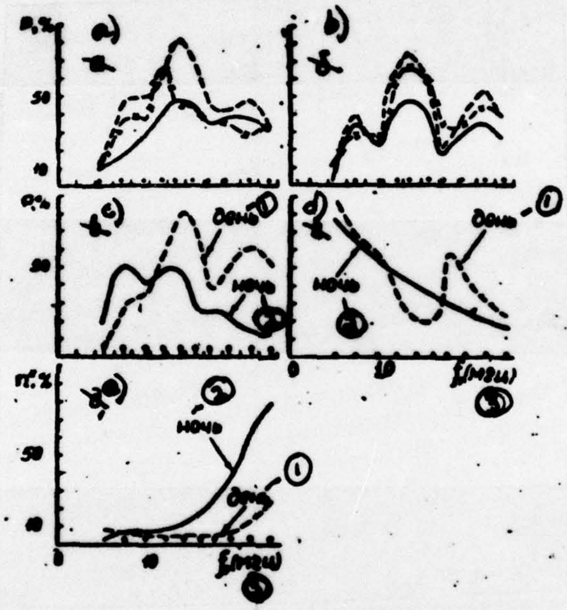

Fig. 2. Distribution of frequency passage probabilities by seasons: 1967 (a); 1968 (b); distribution of frequency passage probabilities for two periods of illumination (c); distribution of interferences for two periods of illumination (d); distribution of the nonpassage cases for a signal due to the preponderance of working frequencies over MUF (e). Key: 1) day 2) night 3) MHz

The distribution of interferences for the day time shows that the number of interferences decreases with a rise in frequecy (up to 12000 kHz), then there is a sharp jump towards an increase (at the 16190 kHz frequency), after this, there is again a smooth decrease. An analysis of the nonpassages of frequencies due to a decrease in the maximum frequencies used in the F2 region (Fig. 2, e, day) shows that the number of non-passages is 2-5% right up to the frequency of 18190 kHz. This permits one to conclude that in a given period the nonpassage is caused mainly by the presence of interferences. At night the passage of frequencies is somewhat different. Low frequencies pass better than they do during the day and better than the high frequencies. Thus, at the frequency of 4560 kHz, P=20% at night and during the day P=5%; at the frequency of 6955kHz P=50% at night and during the day P=27%. During the night the interferences decrease with an increase in the working frequencies (Fig. 2, d - night), and the nonpassage due to the preponderance of the working frequencies over the MUF-F2 frequencies increases sharply from the frequency of 14000 kHz.(Fig. 2, e - night). Thus, to a considerable degree, the nonpassage of the low frequencies during the night depends on the interferences, and at high frequencies - on the MUF-F2.

Conclusions

1. The best passage of radio frequencies in the short-wave range was observed in the frequency interval from 11000 to 15000 kHz.

2. There is a seasonal dependence in the passage of radio frequencies.

3. The passage is better during the day, than at night.

4. During a 24-hour period we have observed a considerable intensity of the interferences at the working frequencies.

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