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LOSSES WITH THE SCATTERING OF SHORT RADIO WAVES IN THE LOWER IONOSPHERE (U)  
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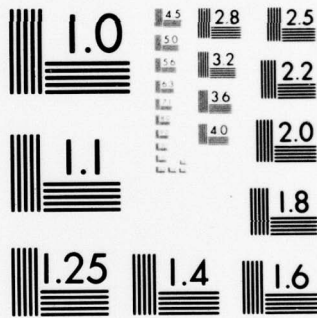
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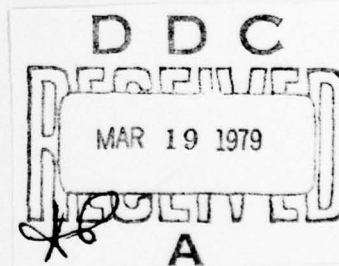
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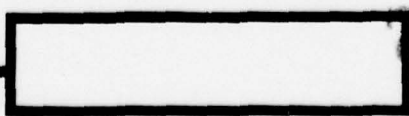
LOSSES WITH THE SCATTERING OF SHORT RADIO WAVES  
IN THE LOWER IONOSPHERE

by

Ya. F. Ashkaliyev



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# EDITED TRANSLATION

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LOSSES WITH THE SCATTERING OF SHORT RADIO WAVES  
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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

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

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

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh <sup>-1</sup>
cos	cos	ch	cosh	arc ch	cosh <sup>-1</sup>
tg	tan	th	tanh	arc th	tanh <sup>-1</sup>
ctg	cot	cth	coth	arc cth	coth <sup>-1</sup>
sec	sec	sch	sech	arc sch	sech <sup>-1</sup>
cosec	csc	csch	csch	arc csch	csch <sup>-1</sup>

Russian      English

rot      curl  
lg      log

## LOSSES WITH THE SCATTERING OF SHORT RADIO WAVES IN THE LOWER IONOSPHERE

Ya. F. Ashkaliyev

Mean losses during the propagation of radio waves due to scatter on ionization heterogeneities of the lower ionosphere were determined on the basis of data from measurements of field intensity on routes with a length of 1000 (16.2 MHz), 1400 (18.3 MHz), and 1700 (16.2 MHz) km [1].

On these routes, losses during scattering were calculated as

$$P = 10 \lg P_1/P_2 - \epsilon_1, \text{ dB} - \epsilon_2, \text{ dB} - 20 \lg 4\pi d/\lambda \quad (1)$$

Here  $\epsilon_1$  and  $\epsilon_2$  - the gain of the receiving and transmitting antennas;  $P_1$  - the power which is fed to the transmitting antennas;  $P_2$  - the power which is extracted by the receiving antenna from the field  $S$  of arriving wave;  $d$  - the length of the route, and  $\lambda$  - the wavelength.

The mean received power  $P_2$  was determined using the equation

$$P_2 = 10^{-12}/z_0 A (4\pi)^2 E^2 \mu V/m^2 \quad (2)$$

where  $z_0$  - the wave impedance of free space;  $A$  - the effective area of the receiving antenna;  $E$  - the intensity of the field.

Losses during scattering were calculated in accordance with the known  $P_2$  for each hour of the day during the entire observation period. Then the median values by months were found from the diurnal course to disclose the mean monthly values.

Figure 1 presents the diurnal course of losses during scattering for those months when propagation was completely caused by normal scattering. Losses during scattering on a route of 1400 km are somewhat less than on the longest route of 1700 km. The minimum losses are found during the daytime hours. The depths of the diurnal variations has a clearly expressed dependence on the length of the route. Thus, for a route with a length of 1000 km the diurnal fluctuations in losses during scattering equal 8 dB, for a route of 1700 km - 12 dB. On a route of 1400 km, these variations comprise only 5 dB. This indicates that on this route the turbulent component predominates over the meteoric.

Comparing losses during scattering which are observed on routes of different lengths - 1000 (16.2 MHz) and 1700 (16.2 MHz) km, we see that on the shortest route in all months they exceed an average of 10 dB.

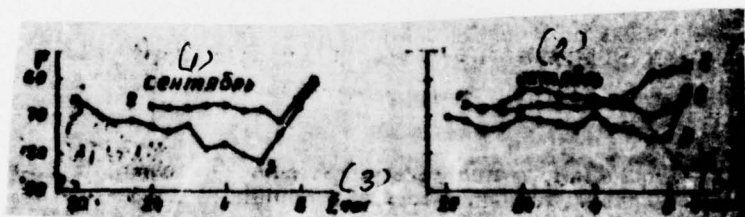


Fig. 1. Diurnal course of losses during scattering: 1 - 1000 km, 2 - 1400 km, 3 - 1700 km.  
KEY: (1) September; (2) October; (3) Hours.

The intensity of the scattered field at the point of reception depends on the frequency of the radio waves. The same heterogeneities of the electron concentration will cause less heterogeneity in the values of the electrical permeability, the higher the frequency.

There are a number of original theoretical works [2, 3] in which it is shown that losses during the scattering of radio waves in the UHF band can be considered proportional:

$$F \sim f^n, \quad (3)$$

where  $F$  - losses in scattering;  $f$  - operating frequency;  $n$  - exponent. Depending on the theory of scattering which is taken, the exponent takes different values [4]. However, for a long time it was not possible to match the observed losses in scattering with a theoretical formula. Only with the appearance of work [5] can it be considered that the experimental data agree satisfactorily with the theoretical relationship. It turned out that relation (2) follows the mean hourly median losses from frequency during the scattering of radio waves on ionization heterogeneities of regions D and E [Translator's Note: It appears that at least one word has been omitted in the Russian text which may affect the clarity of the preceding sentence]. The exponent takes various values depending on the time of day and antenna characteristics. Despite the presence of a large spread of  $n$  values, as is shown in this work,  $n = 5.6$  for the UHF band. Such studies were not conducted in the shortwave band and therefore it is of certain practical interest to clarify whether expression (3) is also satisfied for waves in the HF band.

For this purpose, we recalculated reliable experimental data on losses during scattering which were obtained in the UHF band from formula (2) for frequencies of the HF band of 15-30 MHz depending on the length of the route.

Figure 2 presents the results of the recalculation for four frequencies: 15, 20, 25, and 30 MHz depending on distance for a 99-% excess which are compared with data of the experiment. The triangles show the median value of losses during scattering which was obtained during three months of measurements for a route with a length of 1000 and 1700 km on a frequency of 16.2 MHz while

the crosses show the measurement data on a route of 1400 km at a frequency of 18.3 MHz. It is evident that the losses which are observed in the HF band are somewhat less than the calculated values, by 10 dB. This discrepancy is explained by the fact that we took the median level as the level, i.e., with a 50-% excess.

The table presents the signal level for 1965 with an excess of 10, 50, and 90% for routes with a length of 1400 km in microvolts.

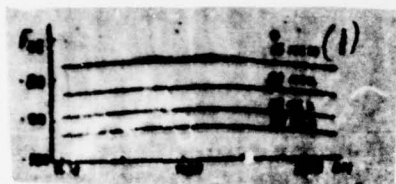


Fig. 2. Losses during scattering depending on frequency and scattering.

KEY: (1) MHz.

The ratio of the median signal level to the minimum equals an average of 10 dB.

Thus, the calculation of lines of ionospheric scatter in the HF band under conditions where we can disregard absorption in the D-layer and the influence of the region  $F(f > 1.4 \text{ MPCh}$  [maximum usable frequency]) of the ionosphere can be conducted using the same equations as for the UHF waves.

Table. Values of mean-monthly medians.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
10	25.0	20.0	24.0	25.0	25.0	24.0	25.0	25.0	25.0	25.0
50	7.0	7.0	9.0	10.0	8.0	7.0	7.0	7.0	7.0	7.0
90	1.5	2.0	2.0	2.7	2.0	1.7	1.0	2.0	2.0	2.0

KEY: (1) Percent of excess; (2) April; (3) May; (4) June; (5) July; (6) August; (7) September; (8) October; (9) November; (10) December.

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