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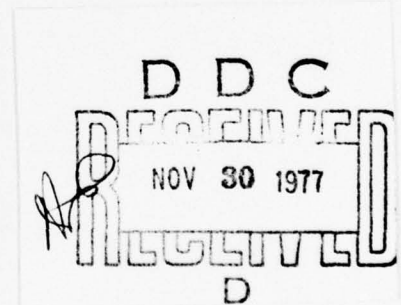
FOREIGN TECHNOLOGY DIVISION



COMMUNICATION IN MILLIMETRIC WAVE BAND

by

V. M. Dmitrachenko



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COMMUNICATION IN MILLIMETRIC WAVE BAND

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

*ye initially, after vowels, and after ь, ь; e elsewhere.
 When written as ë in Russian, transliterate as yë or ë.
 The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α α	α	Nu	Ν ν
Beta	Β β	β	Xi	Ξ ξ
Gamma	Γ γ	γ	Omicron	Ο ο
Delta	Δ δ	δ	Pi	Π π
Epsilon	Ε ε	ε	Rho	Ρ ρ ϱ
Zeta	Ζ ζ	ζ	Sigma	Σ σ ς
Eta	Η η	η	Tau	Τ τ
Theta	Θ θ	θ	Upsilon	Υ υ
Iota	Ι ι	ι	Phi	Φ φ ϕ
Kappa	Κ κ	κ	Chi	Χ χ
Lambda	Λ λ	λ	Psi	Ψ ψ
Mu	Μ μ	μ	Omega	Ω ω

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

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

rot	curl
lg	log

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All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

COMMUNICATION IN ~~4~~ MILLIMETRIC WAVE BAND.

V. M. Dmitrachenko.

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At present in many countries work proceeds on the creation of means of communication/~~connection~~ in millimetric wave band. The main reason for considerable attention to millimetric range is a possibility of designing of the broadband and super wide-band lines for the transmission of high-speed information in digital form, which possess a good freedom from interference and large electromagnetic compatibility with the existing radio-electronics systems.

Are develop^{ed}/~~processed~~ three fundamental new communications in millimetric wave band: super-multichannel waveguide lines, radiorelay lines and satellite lines. Is investigated the possibility of the optimum use of these lines on ~~grid~~/network. For example, for the national systems of satellite communication/~~connection~~ is expedient the application/~~use~~ of waveguide lines for a reception/~~procedure~~^{on} in

~~the distance~~ ^{spaced up} to 20-30 km (radius of the correlation of the spatial distribution of rainfall intensity) ~~of~~ ^{of} antenna. The links of this range, besides independent value, can be utilized for a redundancy, with serious emergencies, waveguide lines. ~~During~~ ^{In} the composite use of the means indicated is possible the construction of ~~grid~~ network with the minimum use of terminal equipment for the coupling of the linear circuits of these means.

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By selecting the same values of the carrier frequencies of the radio trunks and some speeds of transmission, it is possible to produce the couplings of linear ~~circuits~~ ^{channels} directly in working frequency band.

For the developing integral communication networks is develop~~processed~~ the large complex of equipment for transmission and commutation of information, transmitted in digital form. It is known that the fundamental form of modulation ~~accepted~~ ^{is} ~~impulse-coding~~ ^{PCM} modulation (PCM [~~code~~ - pulse-code modulation]). Are created and are operated in a number of the countries ~~of a system~~ of the type IKM-12, IKM-24, IKM-30. Are develop~~processed~~ ^{ed} systems of the type IKM-120, IKM-480, IKM-1000. Is created universal system PCM for the transmissions of all forms of information with capacity from 240 ~~that~~ ^{to} 960 Mbit/s.

The working pulse duration at such rates lies ~~within~~ ^{of} within limits 1-5 ns. For the undistorted transmission of such ~~momentum/impulse/~~ pulses the passband of linear circuit must be order 250-500 MHz, and on the radio-spectrum - on the order of 500-1000 MHz. Actually this band can be obtained either ~~during~~ ^{with} the use of coaxial cables, or ~~during~~ ^{with} the use of a millimetric range of ~~will.~~ ^{waves.}

~~In~~ ^{During} the transmission of such narrow pulses on ~~all~~ cables the length of repeater section ~~descends~~ ^{is decreased} to 1-1.5 km, sharply ~~grow~~ rises the number of regeneration amplifiers, ~~descends~~ ^{low} the reliability of ~~circuit~~ ^{channel}, is raised its cost.

In the millimetric wave band ~~of~~ ^{means of} communications they can have the following fundamental characteristics.

(1) Волноводные линии связи (ВЛС)

- (2) Диапазон рабочих частот 30—100 Гц (3) (5)
- (4) Ширина полосы радиоствола 300+1000 МГц (5)
- (6) Число дуплексных радиостволов до 30 (6)
- (7) Пропускная способность одного радиоствола до 10 000 эквивалентных ТФ каналов (8)
- (9) Общая пропускная способность линии до 250 000 телефонных каналов (9)
- (11) Передача информации в цифровой форме:

 - (12) — со скоростью от 100 до 960 Мбит/сек (13)
 - (14) — с вероятностью ошибки не более 10^{-6} (15)

- (16) Направляющая среда — круглый волновод на волне типа H_{01} с затуханием 2+3 дБ/км (17)
- (18) Длина усилительного участка 15+20 км
- (19) Вид модуляции несущей ИКМ-АМ, ИКМ-ФРМ
- (20) Мощность передатчика 0,1+0,5 Вт (21)
- (22) Фактор шума приемника 10+12 дБ (23)
- (23) Отношение сигнал/шум при ошибке не более 10^{-6} :
 - (24) для ИКМ-АМ не менее 23 дБ (23)
 - (24) для ИКМ-ФРМ не менее 15 дБ (23)

(26) Радиолинейные линии связи (РРЛ)

- (2) Диапазон рабочих частот 36—40 Гц (3) (5)
- (4) Ширина полосы радиоствола 300+500 МГц (5)
- (6) Число дуплексных радиостволов до 5+6 (6)
- (7) Пропускная способность одного радиоствола до 5000 ТФ каналов (7)
- (9) Общая пропускная способность линии до 20 000 ТФ каналов (7)
- (11) Передача информации в цифровой форме:

 - (12) — со скоростью от 100 до 480 Мбит/сек (13)
 - (14) — с вероятностью ошибки не более 10^{-6} (15)

- (8) Длина усилительного участка:
 - (28) — 8—10 км без пространственного разноса станций
 - (29) — 15—20 км с пространственным разносом до 20—30 км (30)
- (9) Вид модуляции несущей ИКМ-ФРМ, для однопролетных линий можно использовать ЧМ

- (20) Мощность передатчика 0,3—1 Вт (21)
- (22) Фактор шума приемника 10—12 дБ (23)
- (31) Отношение сигнал/шум при ошибке
не более 10^{-6} для ИКМ-ФРМ (32)
- (32) не менее 25 дБ диаметр 1,5—2 м
- (34) Антенна: (33) усиление 50—60 дБ (23)
- (35) Источники питания (36) высота 30—50 м
- (37) (при отсутствии близких ЛЭП) . (38) термогенераторы с
подогревом от га-
за .

Key: (1). Waveguide lines of communication/~~connection~~ (VLS). (2). Operational frequencies band. (3). GHz. (4). Width of the band of radio trunk. (5). MHz. (6). Number of duplex radio trunks. (6a). to. (7). The capacity of one radio trunk. (8). to 10000 equivalent TF channels. (9). ~~General~~ ^{Total} capacity of line. (10). to 250000 telephone channels. (11). Transmission of information in digital form. (12). with speed. (13). from 100 to ⁹⁶⁰ Mbit/s. (14). with the probability of error. (15). ~~it is not more~~ ^{than}. (16). Directing medium ~~is~~ circular waveguide on a wave of the type H_{01} with attenuation. (17). dB/km. (18). Length of repeater section. (19). the form of carrier modulation. (20). Power of transmitter. (21). W. (22). Signal-to-noise ratio with error ~~is~~ ^{of} not more ^{than} (23). dB. (24). for. (25). ~~it is not less~~ ^{than} (26). Radio-linear lines of communication/~~connection~~ (RRL [99sp03 - radio relay line]). (27). to ⁵⁰⁰⁰ TF channels. (28). 8 - 10 km without the ~~three-dimensional~~/space separation of stations. (29). 15-20 km with ~~three-dimensional~~/space separation. (30). for single-span lines it is possible to utilize FM. (31). Signal-to-noise ratio with error ~~is~~ ^{of} not more than 10^{-6} for IKM-PRM. (32). diameter. (33). amplification. (34). Antenna. (35). Power supplies. (36). height ^{of 30-50 m} ~~altitude~~. (37). (in the absence of close LEP). (38). thermal converters with preheating from gas.

Equipment can be ~~arrange~~ located or on mast or below.

For antenna feed it is possible to use ~~plumbing~~ ^{waveguide channel} in wave H_{01} with complete attenuation ^{of} not more than 2-3 dB ^{at} 100 m.

Communicating systems through ISZ [~~998-03~~ ^{UC3} - artificial earth satellite].

It is known that the communicating systems through ISZ are divided into global and local. Millimetric wave band is assumed to utilize for all forms of communication through ISZ. For example, firm Bell proposed the project of super-multichannel satellite system with the use of a series of the low-flying satellites. Is carried out at present experiment in millimetric range on satellite ~~at S-F.~~ ^{AT-5} is plan ^{with} ~~glides~~ experiment with satellite ^{AT} S-F. Experiment and the calculations show that it is possible to expect the following parameters of the line through ISZ in millimetric wave band ^{with} ~~at~~ the transmission of the digital information:

- (1) Диапазон рабочих частот Земля — (2)
спутник 29—31 Гц
- (3) Диапазон рабочих частот спутник — (2)
Земля 40—41 Гц
- (4) Для обоих направлений возможно ис- (2)
пользовать 36—41 Гц
- (5) Ширина полосы радиоствола (5) до 500 Мгц (6)
- (7) Число стволов (8) до 4—5 (10)
- (9) Пропускная способность одного (9) до 5000 ТФ кана-
ствола ствов (10)
- (11) Передача цифровой информации со (11) от 100 до 480
скоростью Мбит/сек (13)
- (14) Вид модуляции несущей ИКМ-ФРМ
- (15) Мощность передатчика спутника 2—5 вт при диа-
метре антенны (16)
10 м и порядка (17)
40 вт при диамет-
ре 2,5—3 м (18)
- (19) Коэффициент шума приемника спут-
ника 8—10 дБ (20)
- (21) Мощность передатчика наземной (21)
станции 1 кВт при диамет- (22)
ре антенны 10 м
- (23) Температура шума приемника назем- (24)
ной станции порядка 200°K

Key: (1). Operational frequencies bands ~~to~~ Earth - satellite. (2). GHz. (3). Operational frequencies bands ~~to~~ satellite - ~~the~~ Earth. (4). For both directions it is possible to utilize. (5). Width of the band of radio trunk. (6). MHz. (7). Number of ~~shafts~~ ^{trunks}. (8). to. (9). The capacity of one ~~shaft~~ ^{trunk}. (10). channels. (11). Transmission of digital information with speed. (12). from. (13). Mbit/s. (14). Form of carrier modulation. (15). Power of the transmitter of satellite. (16). 2-5 W with the diameter of antenna. (17). 10 m order. (18). 40 W with diameter 2.5-3 m. (19). Coefficient of receiver noise of satellite. (20). dB. (21). Power of the transmitter of ground station. (22). 1 kW with the diameter of antenna 10 m. (23). Noise temperature~~s~~ of the receiver of ground station. (24). order 200°K.

In such averaged parameters of system and for the ~~middle~~ ^{average} climatic zone (average intensity of rainfall - 5 mm/h) supplementary gain ~~margin~~ ^{reserve} must be not less than 15-20 dB. Without this reserve the communication line can be disabled ^{up} to 40 h per annum. However, the application ~~use~~ of the diverse reception ~~procedure~~ on the order of 20-30 km in distance lowers time of unfitness for ~~work~~ ^{operation} to 10-20 min per annum.

Technical bases of the creation of the millimetric lines.

Contemporary radio-electronics industry virtually mastered and approached toward the issue of active and passive ~~equipment~~ devices of millimetric range, on the basis of which it is possible to create the millimetric communication lines with the parameters indicated.

In many countries for the waveguide communication lines are developed special circular waveguides on wave H_{01} with attenuation in range 30-100 GHz on the order of 2-3.5 dB/km. On their basis are constructed and tested experimental lines up to 20 km long. Plan ~~is~~ ^{is} the construction of waveguide lines with length up to several hundreds of kilometers.

Are developed ~~the specimen/samples~~ ^{models} of transceivers for amplification and regeneration in the millimetric wave band of signals IKM-FRM at rate to 960 Mbit/s. These transceivers are created with the application ~~use~~ of the newest semiconductors SHF [^{CB4} ~~990-003~~ - superhigh frequency] and integral SHF ~~equipment~~ devices: avalanche-and-transit diodes, ^{diodes} on the effect of Hann, diodes with the barrier of Schottky, ^{band} microcircuit circuits, etc. Are developed also tubes with the traveling wave at power up to several dozen watt.

Is created ~~by the gamma~~^{at} of very high speed integrated circuits with operating speed more than 200 MHz. On their basis are developed the ~~specimen/samples~~^{models} of terminal equipment with ~~impulse coding~~ modulation for the transmission of the different forms of information.

Are constructed and test^{ed} the experimental ~~lines~~^{radiorelay lines} of millimetric ~~band~~^{with throughput up} capacity to of several thousand equivalent telephone channels. Are investigated the statistic^{ion} of the ~~three-dimensional~~^{spatial} and time/~~temporary~~ distribution of the rains, which determine fading ~~of~~ signal and, therefore, the fundamental parameters of the lines.

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