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FOREIGN TECHNOLOGY DIVISION

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(SELECTED PORTIONS)

By

V. V. Kulikov

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EDITED TRANSLATION

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MODERN SYSTEMS OF WIRELESS LONG-RANGE COMMUNICATION (SELECTED PORTIONS)

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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

MODERN SYSTEMS OF WIRELESS LONG-RANGE COMMUNICATION

V.V. Kulikov

ABSTRACT

This book is about the radio-relay, tropospheric and satellite wireless systems of long-range communication. Besides the basic characteristics of the principle of construction and a brief history of these rapidly devcloping types of communication, the book reveals the means of the approach to the provision of the normalized qualitative indices of the channels, to the solution to the problems of reliability, the high actual transmitting capacity and the great length of the lines. A block diagram is given of the devices which reflect the contemporary level of the development of the systems named, a brief description of the most characteristic of them is given, and the modern views on prospects of their development are underlined.

The book is written for a comparatively wide range of readers who are interested in the problem of electrical communications, but it contains a great amount of reference material and a systematic account of the general problems and can be useful also for specialists in the field of electrical communication and also for students of educational institutions.

Editor-in-Chief
Corresponding Member of the Academy of Sciences of the USSR
V.I. Siforov

COMMENTS OF THE AUTHOR

Problems of the state and development of systems of electrical communication and, in particular, systems of wireless long-range communication, for a long time have fallen outside the limits of the interests and activity of a narrow range of specialists. The modern equipment contains assemblies, devices, instruments, parts, and materials developed by engineers of many dozens

of "related" specializations. Such equipment is the result of the activity of specialists of a vast list of comparatively narrow professional lines. Due to the lack of time the specialists of these categories are not always able to become familiar with the range of problems which are before the very developers of the communication systems according to the fundamental special works and articles in the periodic publications of the Soviet and foreign press. These sources and works are almost inaccessible for technical personnel of the communication enterprises, for students of the tekhnikums [techical schools] of communication, and also for persons who are interested in electrical communication but not having a sufficient general theoretical training.

In the proposed book, in a concentrated form and in an accessible form but without oversimplification, the author tried to give an account of the basic information about wireless systems of long-range communication.

The author wishes to express his deep appreciation to the reviewer of the book, Candidate of Technical Sciences, senior scientific collaborator, I.A. Gusyatinskiy, and also to V.I. Vasil'yev, Candidate of Technical Sciences Ye.A. Volkov, Candidates of Technical Sciences, lecturers S.I. Konyukovskiy and Ye.V. Spirov for the reading of the manuscript and the number of valuable (to the author) comments and wishes expressed by them, which are taken into account in the preparation of the manuscript for printing.

The author will appreciate any comments and wishes. Please send them to the address of the publishing house: Moscow, K-62, Podsosenskiy Lane, 21, "Nauka" Publishing House.

INTRODUCTION

The rapid development of electronics, the theory and technique of superhigh frequencies, information theory, and a number of other sciences has led to the appearance in the last decade and even in recent years of new and the latest systems of wireless long-range and super long-range communication[1], which allows transmitting for many hundreds and thousands of kilometers television signals, numerous telephone, telegraph and phototelegraph communication, information of computers, and so on. These systems do not yield to, and in many respects exceed, the wire (cable) systems of long-range communication. Used for their operation are ultrashort radio waves (UKV) mainly of the decimeter and centimeter ranges, where it is possible to provide high noise immunity, great transmission capacity and the necessary reliability of the communication lines.[2] The rectilinear nature of

[1]Here and further, understood by this term are only such systems of communication without wires for which characteristic are all the basic properites of the wire (cable) systems of long-range communication: the constancy of the residual attentuation, the low level of the noise, high reliability, two-way telephone operation, and the multichannel nature. It is obvious that, for example, systems of long-range short-wave radio communication do not belong to the systems in question.

[2]Systems of ground communication of the millimeter, submillimeter and optical ranges of frequencies (lasers) for the time being are

the propagation of the decimeter and centimeter radio waves causes the need to use intermediate transmission , the so-called relay (from the English relay - shift) stations, which allow extending the length of the communication lines laid between two points on the earth's surface. Therefore, actually all the modern lines of long-range communication belong to the class of radio-relay and consist (or can consist) of a number of relaying intervals on the joints of which the "retransmission" of the signals is carried out. The relaying intervals along their length extremely greatly depend on the principle of operation of the systems of wireless communication used on the intervals. Known at present, essentially, are two classes of systems of radio communication using ultrashort waves: a) systems which use for the communication the "direct" wave radiated by the antenna of the transmitter; b)sytems which use waves reflected from any objects or heterogeneities of the troposphere or ionosphere.

Systems of the first class require the presence of "direct" (quasi-optical) visibility between two stations or relayers. They They comprise the basis of the radio-relay lines of direct visibility ard communication lines in which there are used highly located active relayers, for example, on artificial earth satellites (ISZ).

Belonging to systems of the second class are those which use waves reflected, for example, from the moon, from the metallized surface of the satellite, from ionized tracks of micrometeorites which have burned up, and from the mass of elementary metallic dipoles ejected into space, and also the diffusely reflected

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used only on the experimental, relatively short communication lines. The reasons for this are covered, on the one hand, in the still insufficient perfection of the equipment and, on the other hand, in the noise for communications created by the rain, fog, snow, atmospheric dust, and light background of the sun, moon and stars. Nevertheless, recent achievements make it possible to assume that in the future there will appear radio-relay and light relay lines of the mentioned ranges, the main advantage of which will be the colossal transmission capacity.

from the heterogeneities of the troposphere and ionosphere.

The kinds of systems of ultrashort-wave radio communication used on the intervals determine, correspondingly, the names of types of modern lines of the wireless long-range communication, which in accordance with the widespread terminology[3] are subdivided into:

1) radio-relay communication lines (of direct visibility or "standard");

2) tropospheric radio-relay communication lines (beyond-the-horizon);

3) ionospheric communication lines;

4) satellite communication lines (communication lines through the ISZ).

On the intervals of the radio-relay communication lines of direct visibility (Fig. 1), there is almost always provided the quasi-optical visibility between the antennas of the two adjacent radio relayers owing to the construction of sufficiently high antenna supports installed, moreover, on the elevated sections of the terrain. The length of the interval in this case is limited usually to several dozens of kilometers. On tropospheric communication lines (Fig. 2), used as the scattering layers are the layers of the troposphere which are located at an altitude of several hundreds of meters to dozens of kilometers, "visible" simultaneously from points of the location of the tropospheric stations remote from each other, by which the length of the interval these lines is determined. An even longer length of the interval, which reaches one and one-half to two thousand kilometers,is provided by the ionosphericl lines similar in principle with the tropospheric lines located at altitudes of the order of 75-100 km.

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[3]The given terminology is not the only terminology. Thus, for example, in foreign literature radio-relay systems are sometimes called microwave.

The communication lines through the satellite can provide a communication range measured in the many thousands of kilometers.[4] The range depends basically on the flight altitude of the satellite. Used at present for the purpose of communication are practically only satellites with active radio relayers (of the type of the satellite "Molniya-1" and the American satellite, "Early Bird." Satellites with passive radio relayers (of the "Echo" type), used as simple reflectors of radio waves for the time being do not provide the necessary quality of communication, although they fundamentally have a number of advantages.

Systems of wireless long-range communication are rapidly being developed and perfected together with the wire (cable) systems, not displacing but supplementing the latter and forming in the complex a more flexible and branched single communication network.

The wireless systems of long-range communication possess a number of characteristic merits:

radio-relay lines of communication of direct visibility do not yield in transmission capacity to the cable lines but at the same time require lesser periods of time for construction and incomparably less expenditures of valuable nonferrous metals (lead, copper); as a whole usually lines of such type are cheap cable lines;

tropospheric and ionospheric relay communication lines are not interchangeable in regions which are almost inaccessible and little populated, in deserts, in the Arctic, where communication on short waves is unstable, in regions near seas, and in the oceanic archipelagoes;

the satellite relay communication lines allow with one jump to overlap thousands of kilometers, providing the high-quality transmission of all forms of signals; modern satellite systems of communication completely are justified from an economic viewpoint, being favorable and reliable systems of communication.

[4] With one relaying through the satellite - up to 17-18 thousand kilometers.

The advantages of satellite communication systems put this form of long-range communication in first place. This is a single form of communication system which provides free transmission through the oceans and continents of standard and color television. Virtually only this form of communication will allow in the nearest future solving the problem of global communications and provide the growing needs in the exchange of all forms of information between the continents and countries.

In the Soviet Union, which covers an enormous territory, a great deal of importance is given to the development of systems of long-range communication of all forms. During the years which passed from the time of the 20th Congress of the CPSU, when the task was set to provide in a short time period development of radio-relay communication in the country, there was created the gigantic network of the Central Television of the Soviet Union, which connected the television centers of Moscow, Leningrad, Tallin, Riga, Vil'nyus, Kaliningrad, Smolensk, Minsk, Kiev, L'vov, Kishinev, Odessa, Khar'kov, Dnepropetrovsk, Simferopol', Sochi, Tbilisi, Baku, Gor'kiy, Perm', Chelyabinsk, Sverdlovsk, Tashkent, and a number of other cities.

A considerable part of this network (tens of thousands of kilometers) is made in the form of radio-relay communication lines. The network of radio-relay and coaxial cable lines of the USSR are connected with the international networks "Intervision" and "Eurovision ", which connect the socialist and other countries of Europe.

In accordance with the resolutions of the 23rd Congress of the CPSU, which posed the problem of the further development and improvement of the means of communication, broadcasting and television, including the creation of systems of communication and television by means of satellites and radio relayers, an extensive network of ground stations of the satellite communication system "Orbit" is being constructed in our country. Because of this system, engaged into the network of Central Television through the ISZ "Molniya-1" are the remote regions of the Far North, Siberia, Far East, and Central Asia.

By the 50th Anniversary of the Great October Socialist Revolution more than 20 ground stations of the "Orbit" system were put into operation: in Moscow, Vladivostok, Magadan, Yuzno Sakhalinsk, Komsomol'sk on Amur, Yakutsk, Novosibirsk, Vorkut, Syktyvkar, Kemerovo, Bratsk, Noril'sk, Khabarovsk, Ulan Ude, Chita, Anadyr', Surgut (under Tyumen'), Murmansk, Arkhangelsk, Petropavlovsk-on-Kamchatka, Krasnoyarsk, Irkutsk, Ashkhabad, and Frunze. The number of ground stations will increase continually.

The use of lines of long-range communication of all forms in a complete set makes it possible to solve successfully the problem of creating a single automated system of electrical communication of the Soviet Union (YeASS). This system will organizationally and technically join the city, rural, intraregional, and main networks of communication and connect into a single system the overhead, cable, radio-relay, ionospheric, tropospheric, and satellite lines of communication.

In the near future an extensive exchange of radio and television programs through communication satellites with foreign countries will be carried out.

An important step in this direction is the exchange of experimental transmissions of color television by the system of SEKAM 3 between the USSR and France within the framework of the known agreement on collaboration of Soviet and French scientists. From reports of the press, plans of the creation of a space bridge of communication between the USSR and Cuba are known.

In speaking about the development of systems of wireless long-range communication, it is important to note the very great and valuable contribution made in this field by the Soviet scientists V.A. Kotel'nikov, V.I. Siforov, S.V. Borodich, V.A. Fok, B.A. Vvedenskiy, A.G. Arenberg, A.I. Kalinin, I.S. Gonorovskiy, V.A. Smirnov, N.M. Izyumov, L.M. Fink, N.D. Devyatkov, V.R. Kovalenko, and also many Soviet scientists with whose names is associated the development of the numerous branches of science on which the technology of long-range wireless communication is based.

Soviet scientists have published numerous scientific articles

and monographs devoted to the working out of certain problems of the theory and technique of radio-relay, tropospheric and satellite communication. A number of special handbooks and training manuals have been written, and they contain detailed theoretical and practical material on the problems of ground and space wireless communication and also a very large bibliography.

For readers who are interested in such kind of works and bibliographies on the problems of wireless long-range communication, it is possible to recommend books which are indicated in the literature list.

Fig. 1. Diagram of a radio-relay communication line of direct visibility ("standard" radio-relay line)
KEY: 1) Dozens of km, up to 70-100 km); 2) Sea level;

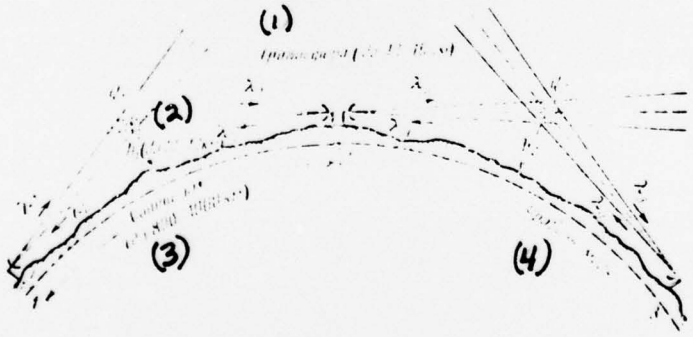

Fig. 2. Diagram of the tropospheric radio-relay communication line (with the beyond-the-horizon location of the stations on intervals with the use of radio waves scattered in the troposphere)
KEY: 1) Troposphere (up to 21-15 km); 2) up to 10-12 km; 3) Hundreds of km (up to 800-1000 km); 4) Sea level.

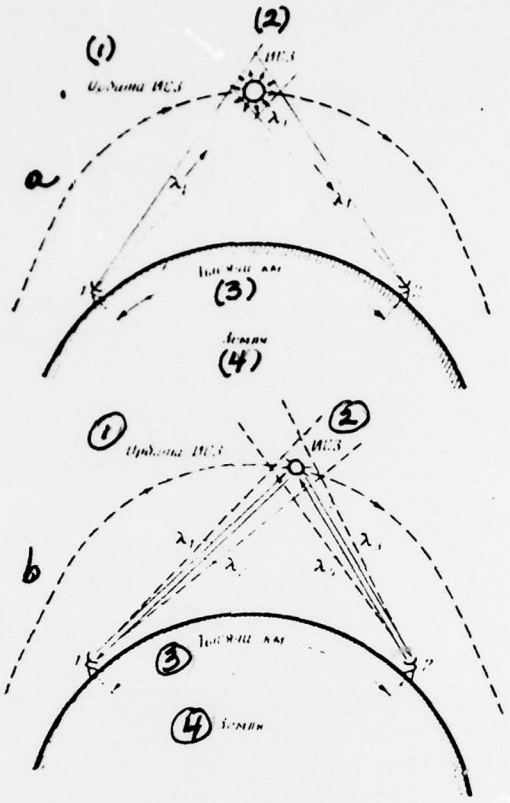

Fig. 3. Diagram of radio-relay communication lines through ISZ: a - with the use of the ISZ as a passive radio relayer; b - with the use of the ISZ as an active radio relayer. KEY: 1) Orbit of ISZ; 2) ISZ; 3) Thousands of km; 4) Earth.

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*The given literature list, compiled in chronological sequence, is recommended for persons who desire a deeper acquaintance with the problems of the theory of radio-relay, tropospheric and satellite communication. The literature list used in the writing of this book (mainly articles and notes from Soviet and foreign periodicals) can not be cited due to it being too long a list.

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