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The Life Filled with Cognition and Action

(Dedicated to the 100th Anniversary of Academician V.A. Kotelnikov)

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Background: Dr. Bykhovskiy is the Deputy Head of the Center of Analysis of Electromagnetic Compatibility at the Radio Research and Development Institute (Moscow), and a historian in the field of telecommunications. He is the author of a book in Russian entitled "Pioneers of the Information Century" and has previously contributed articles on David Middleton and Roland Dobrushin to the IT newsletter. This is a shortened version of the original submitted article.

Just as a horse is born to race, a bull–to plough the land, a dog–to trace, so a man is born for two matters–for cognition and action as a certain mortal God. Aristotle

Introduction

The whole epoch of the development of communications, radio engineering and radio physics is linked with the name of Academician Vladimir Aleksandrovich Kotelnikov. His largest scientific achievements such as the invention of the sampling theorem, the creation of potential noise immunity theory, as well as the development of planetary radars, have all made a deep impact on scientific progress.

Kotelnikov was both an outstanding scientist and teacher. He greatly contributed to the organization of scientific studies in the USSR on many contemporary disciplines of radio engineering and radio physics. He established two large centers, the Special Design Bureau of the Moscow Power Engineering Institute (SDB MPEI) and the Institute of Radio Engineering and Electronics of the Russian Academy of Sciences (IRE RAS).

His life was filled with cognition and action completely corresponding to the concept about the mission of man formulated by Aristotle in the above epigraph.

Biographic Sketch

Vladimir Aleksandrovich Kotelnikov was born on September 6, 1908 in Kazan. His father Alexander Petrovich Kotelnikov – a known Russian scientist in the field of mathematics and mechanics – was a Professor at Kazan University.

In 1930, V.A. Kotelnikov graduated from the radio engineering faculty of MPEI and began his postgraduate study at MPEI. In 1941, he became associate professor of MPEI and joined the Central Telecommunication Research and Development Institute (ZNIIS).

Fundamental radio communication problems at once fell within his view. In 1932, he prepared the report «On transmission capacity of an ether and a wire», where he formulated his sampling theorem – one of the fundamental theorems of communication theory. The report was published in 1933.

In the 1930s, at the initiative of Kotelnikov and under his management, single side band radio equipment was developed and put into operation for the radio link between Moscow and Khabarovsk.

In 1938, Kotelnikov was granted his Master's degree in electrical engineering. In 1939, Kotelnikov started research and development of equipment for crypto protection of telegraph and telephone circuits. In early 1941 he created a prototype of the speech converter similar to the vocoder invented in 1939 by the American engineer H. Dudley, and in June–three days before the beginning of World War II (WWII)–he submitted a classified scientific report which for the first time defined conditions for undecipherability of a crypto system. He also defined technical principles for construction of cryptographically secure systems.

During WWII, under the guidance of Kotelnikov a ciphering system for telephone circuits was developed, which was not deciphered until 1946. It was widely used by the army to communicate between Moscow and the soviet delegation, and was used during the acceptance of the German capitulation in May, 1945. In 1943 and 1946, Kotelnikov and his collaborators were awarded Stalin's Prize of the first degree for the development of the voice ciphering equipment. Issues of cipher security were also studied by Claude Shannon, whose theoretical results were presented in the classified report «A Mathematical Theory of Cryptography» in 1946.

In 1944, Kotelnikov returned to MPEI where he established the Department of Theoretical Fundamentals of Radio Engeneering. Kotelnikov was the head of this department from 1946 until he was elected full member of the USSR Academy of Sciences in 1953, after which he still continued his pedagogical activity.

After the end of the WWII (December 1946), Kotelnikov submitted the doctoral thesis «A Theory of Potential Noise Immunity» to the MPEI academic council. It was successfully defended in January 1947 and became one of the milestones of modern communication science and brought to him world fame.

Kotelnikov also established one of the largest domestic science centres – Special Design Bureau (SDB MPEI). For a number of years he was the SDB chief designer and supervised many important developments. Scientists at SDB MPEI developed multi-channel radio telemeter systems for national rockets, space vehicles, active radar systems, high-precision goniometric systems, and the first space television system.

In 1953, by the initiative of Academician A.I. Berg, the Institute of Radio Engineering and Electronics of the USSR Academy of Science (IRE RAS) was established, with Berg as Director and

Kotelnikov as Deputy Director. In 1954, Kotelnikov became the Director of the IRE RAS. After some years this Institute became the largest scientific centre in the country on the problems of radio engineering and radio physics.

At the IRE RAS, Kotelnikov together with Academicians Guljaev (the IRE RAS Director after Kotelnikov) and Devyatkov devoted attention to studying the theoretical basis of microelectronics, optoelectronics, super-conductivity, semi-conductivity, acousto-electronics and magneto-electronics. IRE RAS scientists also carried out basic research in fiber optic communication systems, radio physical methods for exploration of Earth's natural resources, application of radio electronics in medicine, and automation of scientific studies.

Kotelnikov initiated and supervised studies on a planetary radiolocation and radiation study of Solar system planets and the Space. The complex radio system allowed unique scientific studies to be performed. In the early 1960s, Kotelnikov together with his students and colleagues developed a radio system enabling extremely accurate distance measurement in radar astronomy. It resulted in corrections to the astronomical constant (distance between Earth and Sun) and the dimensions of Solar system.

The fundamental research at IRE RAS led to the first mapping of the surface of Venus. In 1964, he together with his team of colleagues was awarded the Lenin's Prize for their work in the field of the planetary radiolocation. In 1984 – 1992, studies on the accuracy of the relativistic theory of planets movement were carried out under Kotelnikov's scientific guidance.

In 1987, Kotelnikov resigned from the position of the IRE RAS Director and became the Director Emeritus. Until his death, he remained as a Chairman of the IRE Academic Council and ran all its sessions.

Kotelnikov received many scientific awards. The International Institute of Electrical and Electronic Engineers (IEEE) awarded him the IEEE 1973 Award in International Communication in honor of Hernand and Sosthenes Behn for fundamental contributions to communication theory and practice, and for pioneering research and leadership in radar astronomy. Presidium of the USSR Academy of Sciences awarded Kotelnikov the 1974 Popov Gold Medal for contributions to basic research in the fields of communication theory and planetary radiolocation, the 1981 Lomonosov Gold Medal (the Academy's highest award) and the 1987 Keldysh Gold Medal.

For his rigorous pioneering proof of the famous sampling theorem Kotelnikov was awarded the international 1999 Edward Rhein Prize from Germany's Edward Rhein Foundation. For his contributions to communications he was awarded the IEEE 2000 Gold Medal of Alexander Graham Bell, and also the honorable IEEE Third Millennium Medal. Prof. Bruce Eisenstein, the President of the IEEE, characterized him as «The outstanding hero of the present. His merits are recognized all over the world. In front of us is the giant of radio engineering thought, who has made the most significant contribution to media communication development».

Kotelnikov was one of the founders of the Russian Scientific and Technical Society of Radio Engineering, Electronics and Communication named after A.S. Popov, and was the chairman of its Board for many years. Kotelnikov was also a member of the Polish, Czechoslovak, Mongolian, Bulgarian and German Academies of Sciences, IEEE Honorable member, and vice-president of the International Academy of Astronautics. From 1969 till 1988 Kotelnikov was vice-president of the USSR Academy of Sciences, and chaired a number of its councils. For many years Kotelnikov was the editor-in-chief of journals «The Radio Engineering and Electronics» and «The Bulletin of the USSR Academy of Sciences».

Vladimir Aleksandrovich Kotelnikov died on February 11, 2005.

His Scientific Contribution to Communications Theory

The sampling theorem was published by Kotelnikov in 1933. According to this theorem any function with a spectrum limited by frequency F may be represented by the samples taken at $1/2F$ time intervals. Independently, this theorem was invented by English mathematicians E.T. Whittaker and J.M. Whittaker at the beginning of 20th century, and discovered by Claude Shannon in 1949.

Another of Kotelnikov's largest scientific achievements was developing the theory of potential noise immunity. It enabled engineers to theoretically synthesize optimum signal processing and receiving devices for different environments and to determine their feasible qualitative characteristics. American and English scientists A.J. Siegert, D. Middleton, P.M. Woodward and I.L. Davis also independently and greatly contributed in the development and popularization of this theory.

In his PhD thesis, he solved the problem of synthesis of the optimum receiver (i.e. the optimum algorithm for processing of the received signal) given the waveform of the transmitted signal and statistical noise characteristics, and developed the methodology for determination of the optimum receiver noise immunity. His small book (only 150 pages) contained many deep ideas which led to a new approach to building signal receivers.

In 1959 Kotelnikov's translated book was published in the USA. In a book review Prof. N.M. Abramson from Stanford University highlighted Kotelnikov's priority in the theory of optimum signal reception, in the application of multidimensional geometry for interpretation of problems associated with signal reception against the background of the noise, and also in studies of nonlinear filtering of signals against the background of non-uniform noise.

Conclusion

According to A.Einstein the most objective criterion for the validity of a scientific theory is its «inner perfection and external justification». The aesthetic criterion is the deeper and more complex criterion for estimation of scientific achievements from the «inner perfection» point of view. It is based on an intuitive feeling of beauty.

Kotelnikov's theory of potential noise immunity had «inner perfection» in that sense. This theory has also been further developed by many researchers and applied to many practical problems. Thus, it has also received external justification.

But one more aspect should not be overlooked when considering scientific achievements. It is necessary to remember their creators'

huge amount of selfless work, the work that fills their life. German philosopher F. Nietzsche wrote: *«Each serious work has a moral impact upon us. Our effort done to concentrate the attention on a given theme could be compared to a stone thrown into our inner life: the first circle has the insignificant area, than the number of alternating circles is increasing and their area expanding»*.

The life of the outstanding Russian scientist V.A. Kotelnikov is the bright acknowledgement of this important and deep thought.

1. Mark Bykhovskiy, Pioneers of the Informational Era/History of Communication Theory Development, Technosphera, Moscow, 2006.