RADAR COMPLEX IN THE "LUNA-RESOURCE" PROJECT

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INTRODUCTION:

Study of the Moon is an intensively developing direction in space research. The practical importance of the Moon exploration consists in the expansion of knowledge about formation and development of the Solar System; a choice of the disposition places for the future expeditions, the estimation of potential use of lunar resources. The main resource is water ice. Water is important for the activity of the Lunar bases. For this reason, detecting of water ice in subsurface layer of the Moon is a priority problem in lunar researches. Radiolocation is the most efficient methods of subsurface exploration. Drilling in situ is a more accurate method but it is less efficient and more expensive and it can be used to refine the soil structures detected by radar.

Multi-purpose radar complex (RLC-L) is planned to be installed on the orbital module "Luna – Resource 1". RLC-L aims at:

- detection, identification and study of lunar subsurface structures;
- assessment of the dielectric constant of lunar soil;
- localization of places with high conductivity;
- study of large-scale irregularities of the lunar surface;
- registration of electromagnetic radiation in the lunar space.

HARDWARE:

RLC-L complex is developed in cooperation of Kotel'nikov Institute of Radio Engineering and Electronics of the Russian Academy of Science and Special Design Bureau IRE RAS. Designed radar complex RLC-L consists of two subsurface sounding radars: Radar-20 and Radar-200. The main characteristics of locators are given in Table 1 and Table 2, respectively.

Table 1. Radar-20 technical characteristics

- Range of accepted frequencies on the minus 3 dB level	17.5 up to 22.5 MHz;
- Bandwidth of intermediate frequency in an active location mode on the minus 3 dB level	5 KHz up to 5 MHz;
- radiated power, not less than	30 W;
- radiated signal	pulse, chirp signal;
- Duration of a radiated impulse	250 μs;
- Duration of registration of the received signal	350 μs
- Repetition frequency, not less than	1 Hz;
- Range of radiated frequencies on the minus 1 dB level	17 up to 23 MHz;
- Average power consumption, no more	20 W.

Table 2. Radar-200 technical characteristics

- Range of accepted frequencies on the minus 3 dB level	175 up to 225 MHz;
- Bandwidth of intermediate frequency on the minus 3 dB level	5 KHz up to 5 MHz;
- Bandwidth of intermediate frequency in a bistatic location mode on the minus 3 dB level	300 KHz;
- radiated power, not less than	30 W;
- radiated signal	pulse, chirp signal;
- Duration of a radiated impulse	250 μs;
- Duration of registration of the accepted signal	350 μs
- Repetition frequency, not less	1 Hz;
- Range of radiated frequencies on the minus 1 dB level	170 up to 230 MHz;
- Average power consumption, no more than	20 W.

OPERATIONAL MODES:

The work of RLC-L radar complex is planned in three modes.

Mode 1: Radar-20 and Radar-200 will operate in monostatic *mode 1* in the range of 50 to 100 km altitude. Chirp modulation of signals will be used

for active sounding. Radar will determine the structure of the lunar ground to a depth of several kilometers with the vertical resolution not worse than 25 m. Radar-200 is supposed to investigate the surface properties and vertical distribution of physical characteristics in the lunar top layers up to ten meters depth with the vertical resolution of about 1 m. The Radar-20 and Radar-200 radars will operate in succession with a minimum switching time. Received lunar echoes are stored in the onboard memory of the Radar-20 and Radar-200, and then transmitted to the Earth for analysis.

Mode 2: In this mode the radar RLK-L will operate in bistatic regime to study the lunar subsurface structure by use of signals emitted by an Earth-based transmitter.

Mode 3 is applied to study the spatial and frequency distributions of electromagnetic emission produced by cosmic sources.

Radarograms are used for displaying results of radar measurements. They are obtained during the radar's movement along the satellite orbit and show a delay of the reflected signal with respect to time of arrival of the signal scattered from the lunar surface. Influence of reflections from the relief features on the results of subsurface sensing can be removed from radarograms by use of 3-D model of the Moon topography. Parameters of the lunar subsurface structure will be restored by use of special method of inverse problem solution.