Българска академия на науките. Bulgarian Academy of Sciences
Аерокосмически изследвания в България. 11. Aerospace Research in Bulgaria
София. 1994. Sofia

Superhighfrequency twopolarization radiometric system „R-400" on board of the „Priroda" module constituting a part of the „Mir" orbital complex

Todor Nazarsky, Georgi Dimitrov, Chavdar Levchev, Garo Mardirossian, Christo Prodanov

Space Research Institute, Bulgarian Academy of Sciences

Destination

The systematic complex control of the geophysical parameters on a global scale — the monitoring of the state of land, world ocean and atmosphere, as well as the dynamics of these parameters state is one of the most actual tasks of modern geophysical science and practice. The periodical measurement of these parameters — temperature of the surface ocean layer, wind velocity in the atmospheric layer closest to the water surface, cloud cover characteristics, precipitation intensity, vertical temperature profiles, heat flow at the "ocean-atmosphere" boundary etc., are of vital importance to the modern development of geophysics, geography, geology, oceanology, hydrology, meteorology, ecology and climatology. The study of this diversity of parameters, moreover with the necessary accurateness, scale, expressness and operativeness may be accomplished only by the use of remote sensing space methods and technical means.

The major goal of the International Scientific Complex Project (ISCP) "Priroda" [1] is namely to obtain data about the geophysical parameters with high accuracy, reliability and space resolution. In it, there participate Armenia, Bulgaria, Germany, Italy, Poland, Russia, USA, Slovakia, France, Chechia and Switzerland.

Two tendencies may be outlined in the scientific program of the "Pridoda" ISCP: fundamental studies and studies having application character. The fundamental orientation is characteristic of the scientific experiments aimed at

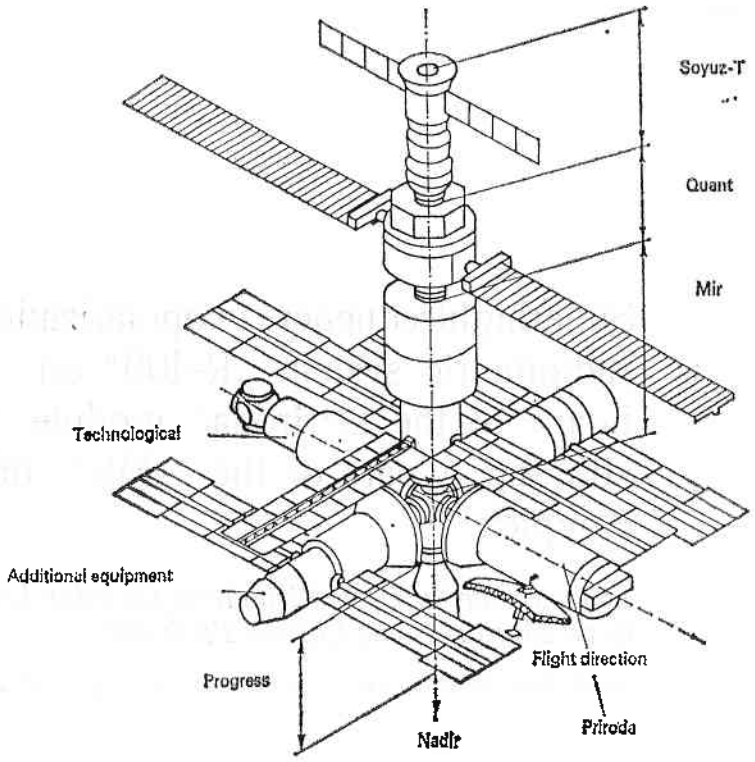

Fig. 1. Scheme of the "Mir" orbital station together with the joined "Priroda" module

studying the cloudiness field, the temperature field of the world ocean surface, the large-scale circulations of the atmosphere, the ocean-atmosphere interaction etc. The application character is typical of the experiments related with the ecologic monitoring of atmosphere, -water and land pollution.

The Scientific Equipment Complex (SEC) by which the above mentioned scientific program is accomplished is mounted on board of the "Priroda" module, specialized for remote sensing geophysical studies, which is joined to the "Mir" orbital station (figs. 1 and 2). The "Priroda" SEC comprises equipment and systems for remote sensing working in the visible, infrared and superhighfrequency range of the electromagnetic spectrum.

A major equipment in the "Pridoda" SEC is the superhighfrequency scanning twopolarization radiometric system R-400 aimed at the measurement of amplitude and space distribution of the own radiothermal emission of the earth's surface in the microwave range. This system has been designed, developed and implemented in the Space Research Institute of the Bulgarian Academy of Sciences.

The data obtained by the R-400 radiometric system provide information about the space distribution of some geophysical parameters: land surface layer humidity, water surface layer temperature, precipitation zone, glaciers

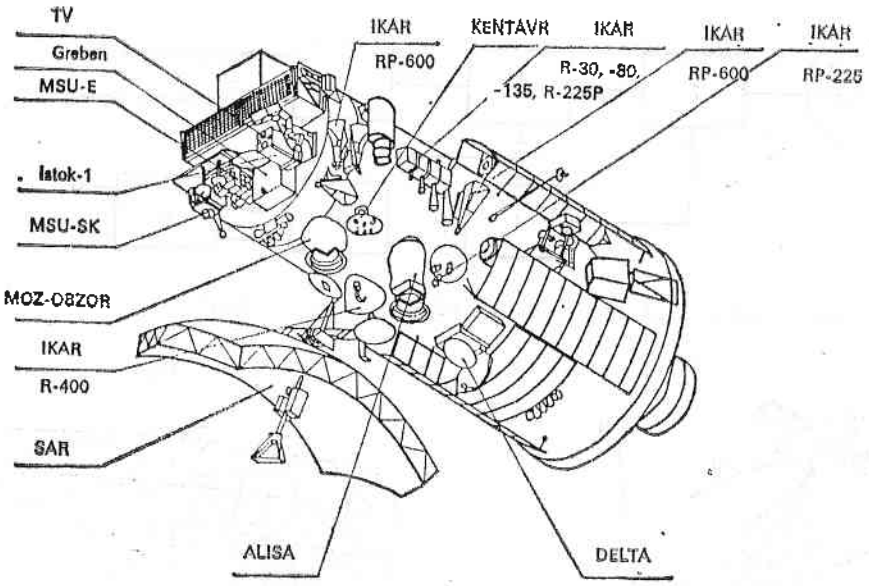

Fig.2

Fig. 2. Scheme of the "Priroda" module

age and floating ices distribution in the polar regions etc. The collective processing of the data obtained by R-400 and the other equipment and systems, constituting the "Priroda" module allow for the solution of a number of scientific-application problems related with the development of a global ecologic monitoring of the Earth.

Structure and principles of operation of R-400

The electrical block scheme of R-400 is outlined in fig. 3 [3]. The major blocks are: *1* — scanning two polarization antenna, *2* — superhighfrequency (SHF) block, *3* — lowfrequency block, *4* — scanning antenna control block, *5* — radiometric system control block, *6* — secondary power-supplying source. Naturally, these are incorporated blocks, each one of them comprising several subblocks.

The own radiation of the studied natural objects is received by a scanning two polarization antenna. The movement of the antenna orientation diagram is a reversive one — in one direction of scanning the horizontal polarization of the earth's surface own radiothermal emission component is measured and in the other direction — its vertical polarization (fig. 4). Besides, the radiometric system's control block gets information about the momentary position of the aperture of the scanning antenna orientation diagram with respect to the examined territory. The SHF signal at the output of the scanning antenna corresponds to the adopted horizontal and vertical components of the measured radiothermal field. This signal is modulated by an adequate low frequency. At the output of the SHF block the received two polarizations of the ra-

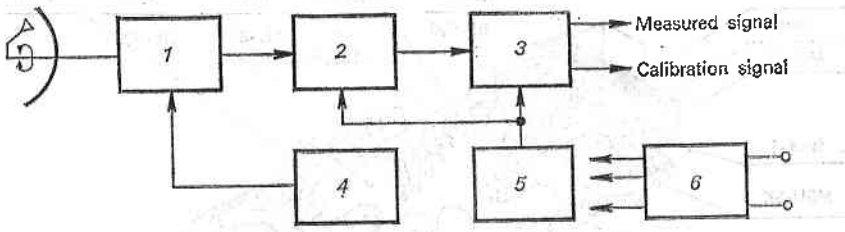

Fig. 3. Outline of the electrical block scheme of R-400

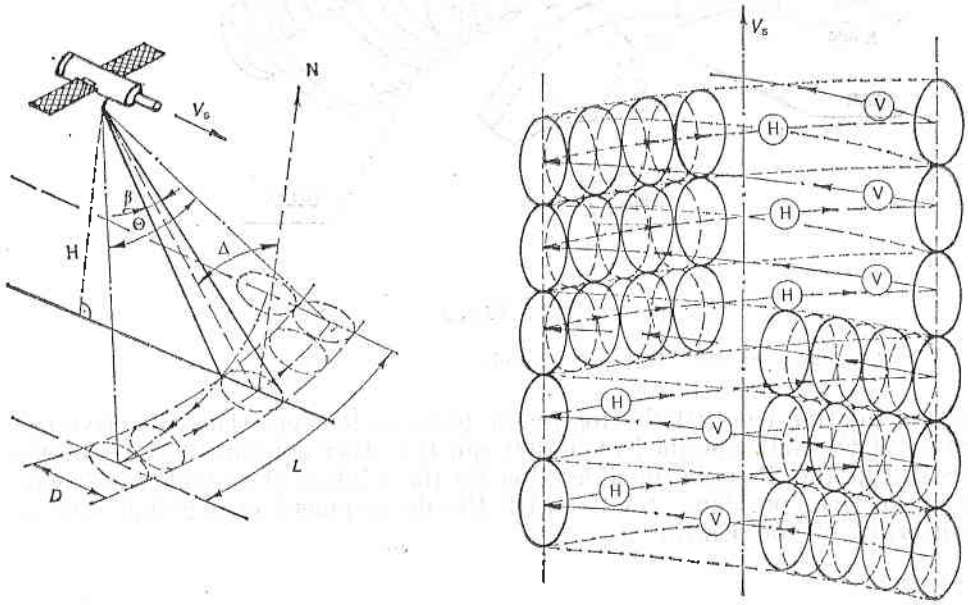

Fig. 4. Scheme of the reversive scanning implementation

diothermal field arrive in succession. In the receiver's mixer the frequency transformation of the received signals is performed after which they are amplified by intermediate frequency, quadratically detected and amplified by the low frequency preamplifier. This signal enters the low frequency block where it is synchronously filtered, amplified and synchronously detected. At the output of the low frequency block the information signal is obtained which is proportional to the horizontal and vertical components of the measured radiothermal emission.

A reference calibration tract is provided for registration of the radiometric receiver gain coefficient fluctuation. The information there obtained enters the algorithm for transformation of the output signals from the radiometric receiver into the physical quantity radiobrightness temperature by which the level of the own thermal emission of the examined objects on the earth's surface.

The blocks controlling the scanning antenna and the radiometric system form the cyclogram of the radiometer's work and the commands for controlling the electric motor of the scanning antenna.

The described principle of operation of R-400 is made possible thanks to a genuine solution [4, 5] with which for the first time simultaneously with the polarization amplitude components of the measured radiothermal field information is obtained about the space coordinates of the objects from the earth's surface that emit them.

Construction

Constructionally, the superhighfrequency twopolarization radiometric system R-400 is constituted by three separate blocks:

— antenna system;
— electronic block;
— connective waveconducting section.

The antenna system is mounted on the outer surface of the "Priroda" module and works in the outer space. It consists of an antenna mirror, an irradiator, a scanning electric motor, a flange and a flexible waveconductor. The antenna mirror has a spherical form, it is made of aluminium sheet with thickness of 3 mm and is attached to the body of the "Priroda" module by the flange. On it, the scanning electric motor is mounted, too. Within the flange, the flexible connective waveconducting section is located by which the SHF connection with the electronic block located within the "Priroda" module is established. The electric connection between the antenna system and the electronic block is effected by two couplings.

The outer appearance of the antenna system of R-400 is shown on fig. 5.

Constructionally, the electronic block represents a parallelepiped box made up of duraluminium alloy with black anoded outer covering. All SHF elements and electronic boards are mounted on a carrying plate. On the front plate of the electronic block there are 6 couplings by which the electrical connection with the business systems of the space station is accomplished.

The outer appearance of the electronic block of R-400 is shown on fig. 6.

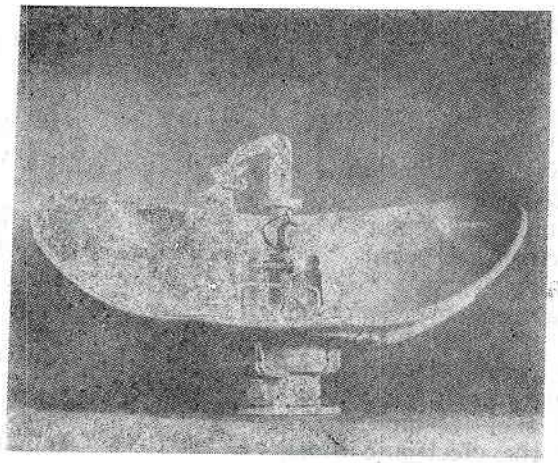

Fig. 5. Outline of the antenna system of R-400

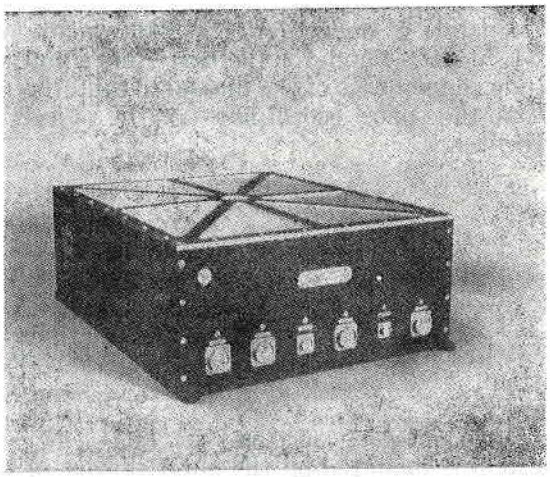

Fig. 6. Outline of the electronic block of R-400

Major technical and exploitation characteristics of R-400

1. Working wavelength	4 cm
2. Fluctuation sensitivity	$\leq$0,15 K
3. Dynamics of the measured radiobrightness temperature	50÷350 K
4. Width of the antenna orientation diagram at level 3 αB	5°
5. Angle of scanning	±35°
6. Angle of measurement with respect to nadir	40°
7. Scope of viewing at orbit height H=300 km	350 km
8. Duration of one image line at orbit height H=300 km	≈3,8 s
9. Number of pixels in one scanning line	40
10. Power supply:	
— voltage	27^{+7}_{-4} V
— power consumption	30 VA
11. Dimensions:	
— scanning antenna	930×750×470 mm
— electronic blocks	400×300×200 mm
12. Total mass	46 kg
13. Temperature:	
— for the antenna system	from —30 to +50°C
— for the electronic block	from 0 to +10°C
14. Pressure:	
— for the antenna system	from 10 to 130 hPa
— for the electronic block	from 600 to 1300 hPa

Scientific problems solved by the data obtained from R-400

Using the data from the SHF twopolarization radiometric system R-400 problems from the following four groups can be solved: land surface study, ocean study, atmospheric studies and ecological studies.

1. Land surface study:
   - 1.1. Snow cover state control and parameters determination.
   - 1.2. Study of the soil cover characteristics.
   - 1.3. Study of the vegetation cover characteristics.
   - 1.4. Study of the basins of big rivers and inner water catchments.
   - 1.5. Mapping of the earth surface in different regions of the electromagnetic spectrum for the purposes of geology.
2. Ocean study:
   - 2.1. Monitoring of the large scale ocean surface temperature field of particular aquatories.
   - 2.2. Working off of methods for determination of wind velocity and direction and wind turbulence characteristics.
   - 2.3. Study of the ocean processes by radiophysical methods.
   - 2.4. Study of the ocean-atmosphere interaction and their influence on the inner continental processes.
   - 2.5. Study of the ice cover.
3. Atmospheric studies:
   - 3.1. Study of the large scale atmospheric processes above the oceans on the grounds of the watercontent field analysis.
   - 3.2. Study of the ocean and the atmosphere in the tropical zone.
   - 3.3. Development of the fundamental remote sensing studies of the "atmosphere-surface" system.
4. Ecological studies:
   - 4.1. Study of the natural complexes in the regions with ecological catastrophies.
   - 4.2. Study of the influence of urbanization and production activity on vegetation and woodcovers.

References

1. Международный целевой комплексный проект „Природа". Научная программа экспериментов. М., 1991.
2. Мардиросян, Г. От космоса срещу екологичните катастрофи. С., БАН, 1993.
3. Сверхвысокочастотная двухполяризационная радиометрическая система Р-400. Техническая и эксплуатационная документация, ИКИ БАН, София, 1993.
4. Назърски, Т., Д. Мишев. Двуполяризационен сканиращ радиометър. Авторско свидетелство за изобретение № 4101/1986, Патентно ведомство на РБ, София, 1988.
5. Назърски, Т., Г. Каменов, И. Сотиров. Диоден вълновиден модулатор. Авторско свидетелство за изобретение № 29259/1979, Патентно ведомство на РБ, София, 1981.
6. Nazarsky, T., G. Dimitrov., Ch. Levchev. An International Complex Project, Exhib. and Techn. Conf. on Ocean and Marine Engineering, Shipbuilding and Maritime Technology, Black Sea'90. Varna 90, p. 240-246.
7. Nazarsky, T., G. Dimitrov, Ch. Levchev. Satellite Microwave Scanning Radiometric System R-400, IGLS, Insbruck, 1992, p. 2A-10 — 2A-13.
8. Nazarsky, T., G. Dimitrov, Ch. Levchev. International Project "Priroda", for Remote Sensing from Orbital Station "Mir", First Eurasian Symposium of Space Sciences and Technologies. MARMARA Research Center — TUBITAK, Turkey, 25-27 November 1993.

Received 20. X. 1993

Свръхвисокочестотна двуполяризационна радиометрична система Р-400 на борда на модула „Природа“ в състава на орбиталния комплекс „Мир“

Тодор Назърски, Георги Димитров, Чавдар Левчев, Гаро Мардиросян, Христо Проданов

(Резюме)

Статията е посветена на свръхвисокочестотната двуполяризационна радиометрична система Р-400, разработена в Института за космически изследвания, БАН. Показано е предназначението на тази система за измерване на геофизични параметри и мястото ѝ в комплекса научна апаратура на специализирания за дистанционни изследвания модул „Природа“, стикован към орбиталната станция „Мир“.

Накратко и в най-общ вид са описани устройството и принципът на действие на радиометричната система Р-400. Дадени са и някои конструктивни параметри и основните технико-експлоатационни характеристики на системата. Изброени са и научните задачи, решавани с помощта на данните, получавани от Р-400.