

RADIOASTRONOMY

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OBSERVATION CONTROL DEVICE FOR THE URAN-4
DECAMETER RADIO TELESCOPE

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ABSTRACT. Since 1986, the URAN-4 radio telescope has been operating at the Odessa Radio Astronomy Observatory of the RI of the National Academy of Sciences of Ukraine. The instrument is an element of a decameter long-base interferometer, the radio telescopes of which are located across the territory of Ukraine from west to east. The radio telescope consists of a 128-element phased array antenna with dimensions of 232.5x22.5 m. The instrument operates in the 10–30 MHz range, and its receiving equipment is capable of separating two polarization components of the received signal. The radiation pattern of the radio telescope is 2.7x22 degrees at 25 MHz. In the interferometer mode, a resolution of 2 seconds is realized. The instrumental complex of the radio telescope includes a device for controlling the operation of the instrument. Structurally, this device is made in the form of a separate unit, in which a board with an ATMEL 8515 microcontroller is mounted with registers and a communication circuit between the unit and a computer. The device carries out, at a given time during the observation period, a discrete movement in space of the antenna directional pattern, sets the required attenuation in the attenuator during calibration measurements. It also allows you to adjust the current time of the computer using GPS, controls the observation process.

Key words: microcontroller, radio telescope, antenna.

АНОТАЦІЯ. В Одеській радіоастрономічній обсерваторії РІ НАН України, починаючи з 1986 року працює радіотелескоп УРАН-4. Інструмент є елементом декаметрового довгобазового інтерферометра, радіотелескопи якого розташовані по території України із заходу на схід. Радіотелескоп складається з 128-елементної фазованої антенної решітки з розмірами 232.5x22.5 м. Інструмент працює в діапазоні 10–30 МГц, і його приймальна апаратура здатна виділяти дві поляризаційні складові сигналу. Діаграма спрямованості радіотелескопу становить на 25 МГц 3x22 градуси. У режимі інтерферометра реалізується розмір у 2 секунди. До складу апаратурного комплексу радіотелескопу входить пристрій управління роботою інструменту. Конструктивно цей пристрій виконано у вигляді окремого блоку, у якому змонтована плата з мікроконтролером ATMEL 8515 з регістрами управління, та схеми зв'язку блоку з комп'ютером. Пристрій здійснює

у заданий час у період спостережень, дискретне переміщення у просторі діаграми спрямованості антени, здійснює установку необхідного загасання у аттенюаторі під час калібрувальних вимірювань. Дозволяє так само здійснити коригування поточного часу комп'ютера за сигналами GPS, та контролює процес спостережень.

Ключові слова: мікроконтролер, радіотелескоп, антена.

Low-frequency radio astronomy is currently being widely developed. It is worth mentioning already built instruments such as Lofar, NenuFAR, the Uran interferometer, UTR-2 and the GURT radio telescope (RT) under construction. For most low-frequency instruments, the antennas are, of different design, phased antenna arrays with discrete control in space directional patterns. Each of these instruments is equipped with radiometers with various receiving and recording equipment and systems for controlling the operation of radio telescopes.

Since 1986, the URAN-4 radio telescope has been operating at the Odessa Radio Astronomy Observatory of the RI of the National Academy of Sciences of Ukraine. The instrument is an element of a decameter long-base interferometer (VLBI), the radio telescopes of which are located across the territory of Ukraine from east to west [1].

The URAN-4 radio telescope consists of 128 broadband turnstile vibrators and is a phased antenna array with geometric dimensions of 232.5 x 22.5 m. It operates in the 10–30 MHz range and is capable of separating two polarization components of the received signal. The radiation pattern of the radio telescope is at a frequency of 25 MHz - 2.7 x 22 degrees. In the VLBI mode of the interferometer, a resolution of 2 seconds is realized. At the same frequency, the instrument's sensitivity in the 14 kHz band is 100 Jy, in the interferometer mode, a sensitivity of about 10 Jy is realized.

The receiving equipment of the radio telescope consists of two sets. One of which, equipped with a frequency and time standard, is used only for VLBI measurements. Another set is represented by a radiometer, which allows the radio telescope to operate in an independent mode. This radiometer operates at two frequencies 20 and 25 MHz. At the same time, it can be used to isolate the received signal in different modes: in modulation mode, total, difference and semi-antenna. In all these cases, various mathematical

combinations are used with the signals received from the two halves of the radio telescope antenna.

Four superheterodyne receivers with a bandwidth of 250 kHz are used as receiving devices of the radiometer. These receivers use synthesizers as local oscillators, which allow them to be tuned to interference-free ranges. A feature of this radiometer is that the incoming signals from the receiving devices are directly digitized at its inputs by a four-channel ADC. All their subsequent transformations are carried out in digital form. As a result, all digital processing of the received signal occurs in two stages.

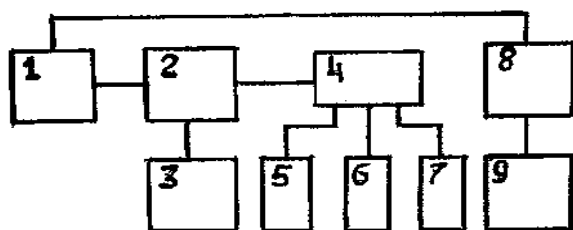


Figure1: Scheme a device for controlling the operation of the radio telescope: 1 – Observation plan; 2 – Computer; 3 – GPS; 4 – Microcontroller; 5, 6, 7 – Control registers RT; 8 – Main control program; 9 – Test the operability of the RT.

The high-frequency part is carried out in hardware, then intermediate data packets are formed, which are transmitted to a computer, where processing is completed in real time. Its results are recorded on the disk and on the monitor screen.

The instrumental complex of the radio telescope also includes a device for controlling the operation of the instrument. Structurally, this device is made as a separate

unit. It contains a board with an ATMEL 8515 microcontroller with a circuit for connecting the unit with a computer and with registers. They are used to control the operation of the radio telescope. The device carries out, during the observation period at a given sidereal time, discrete movement in space of the antenna directional pattern. Sets the required attenuation in the attenuator during calibration measurements. Allows you to correct the current computer time using GPS signals. Controls the monitoring process, recording the current working information to disk and displaying it on the monitor screen. Helps to carry out routine maintenance.

All actions of the control device are carried out on the basis of the upcoming observation plan drawn up by the operator. This plan is entered into the computer and, according to it, the above devices and processes are controlled. The working process itself is carried out by means of the developed working computer programs: microcontroller control program, computer time correction program and directly the main program, which manages the entire measurement process and the recording of current operating information.

Conclusion

The device has been in operation as part of a radiometer for several years and has shown reliable and efficient operation.

Refereces

Galanin V.V. et al.: 1989, *Kinematics and Physics of celestial bodies*, **5**, 87.