**Professional reference on the technical data of the**

**ROT-54/2.6 radio-optical telescope**

**Basic Data**

1. General

|  |  |  |  |
| --- | --- | --- | --- |
| Diameter of the main stationary spherical radio reflector | 54m | Current state | Without changes |
| Working diameter (for the given direction of the antenna beam) | 32m | Without changes |
| Diameter of the small radio reflector | 5m | Without changes |
| Overall error of the radio reflector (RMS error) | 83 mcm | 1mm (rough estimation) |
| Diameter of optical reflector | 2.6m | Without changes |
| The angle of inclination of the entire system to the south | 15˚ | Without changes |
| The geographical longitude of the place (East) | 40˚ | Without changes |
| The geographical latitude of the place (North) | 44˚ | Without changes |

2.Radio-technical

|  |  |  |  |
| --- | --- | --- | --- |
| Minimal length of the wave | | | 1 mm |
| Maximal length of the wave | | | 1m |
| Beam width | on the wave 2 mm | | 14˝ |
| on the wave 8 mm | | 1´ |
| on the wave 20 cm | | 27´ |
| Temperature of the self-noise | on the wave 3 mm and 8 mm (incl. background noise) | | 3К |
| on the wave 3 cm | | 9К |
| on the wave 20 cm | | 12К |
| Geometric surface of the aperture used | | | 800 m2 |
| Antenna aperture efficiency | | on the wave 1 mm (expected) | 0.4 |
| on the wave 2 mm | 0.6 |
| on the wave 8 mm | 0.7 |
| Useful surface | | on the wave 2 mm | 480 m2 |
| on the wave 8 mm | 550 m2 |
| Gain factor | | on the wave 2 mm | 1.5\*109 |
| on the wave 8 mm | 1.1\*108 |
| Aperture angle of the feed | | | 141˚ |
| Shading of the used aperture by the small reflector | | | 2.4% |

3. Optical

|  |  |
| --- | --- |
| Diffraction-limited resolution | 0.2˝ |
| Actual resolution | 2˝ |
| Field angle | 40´х 40´ |
| Undistorted field angle | 10´х 10´ |
| Collecting surface | 5.3m2 |
| The image sizes of point objects | 2˝ - 3˝ |

4. Guidance

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Apical angle of the conical view | | | | 120˚ |
| The declinations of the observed sources | | | from | -35˚ |
| to | +85˚ |
| Guidance rate, maximal | | | | 40˚/min |
| Acceleration, maximal | | | | 1.3˚/sec2 |
| Guidance error | Manual mode (digit. dialling) | | | 3˝ |
| Automatic mode by computer | | | 3˝ |
| Fine manual correction | | | 1˝ |
| Support errors | Automatic mode by computer | | | 2˝ |
| Adjusted fine manual correction | | | 1˝ |
| Video-guide №1 | | Field angle | | 2˚х 2˚ |
| Diameter of the lens | | 30 mm |
| Apparent star magnitude | | 4 |
| Video-guide №2 | | Field angle | | 2.5˚х 2.5˚ |
| Diameter of the lens | | 250 mm |
| Apparent star magnitude | | 12 |

5. Main radio reflector of the antenna

|  |  |
| --- | --- |
| Diameter of the reflector | 54m |
| Shape of the reflector | hemisphere |
| Curve radius | 27m |
| Inclination of the entire dish to the south | 15˚ |
| Number of reflector panels | 3800 |
| Panel material | Alloy of allum. and zinc |
| Panel technology | Casting and mechanical treatment |
| Average weight of the panel | 80 kg |
| Average size of the panel | 1m х 1m |
| Number of the panels sizes | 36 |
| Accuracy of the panel surface (RMS error) | 10 mcm |
| Accuracy of the reciprocal array of the panels | ±100 mcm |
| Width of the gaps between panels (aver.) | 2 mm |
| Total error of the main reflector surface (RMS error) | 58 mcm |
| Distance of the panels from the concrete bowl | 1.8 m |
| Length of the panel mounting legs | 1.8 m |
| Diameter of the concrete hemispheric bowl | 60 m |
| Thickness of the concrete bowl | 1.5 m |
| Total weight of the concrete | 15,000 t |
| Total weight of reinforcement | 500 t |
| Total weight of aluminium | 360 t |
| Total volume of excavation | 70,000 m3 |
| Total volume of backfill | 57,000 m3 |

6. Small radio-reflector of the antenna

|  |  |
| --- | --- |
| Diameter of the reflector | ≈5m |
| Depth of the reflector | ≈ 2.5m |
| Shape of the reflector | special |
| Distance of the center of the main reflector from the top of the small reflector | 13.5m |
| Distance of the small reflector top from the focus | 3.4m |
| Surface of the small reflector’s aperture | 19.6 m2 |
| Frame | Steel, hard |
| Number of reflector panels | 170 |
| Panel material | titanium |
| Panel technology | Mechanical treatment |
| Average sizes of the panels | 70 х 40 cm |
| Accuracy of the panel surface | 15 mcm |
| Reciprocal array of the panels | By the copier |
| RMS error of the small reflector’s surface | 60 mcm |
| Total weight of the small reflector | 15 t |

7. Optical telescope

|  |  |
| --- | --- |
| Diameter of the main reflector | 2.6 m |
| Shape of the reflector’s surface | parabolic |
| Primary focal length | 10 m |
| Material of the main reflector | Glass ceramics |
| Ratio of the focal length to the diameter | 3.85 |
| Light-gathering power | 0.26 |
| Weight of the main reflector | 4.2 t |
| Number of unloading mechanisms | 28 |
| Diameter of the secondary reflector | 0.4 m |
| Shape of the secondary reflector’s surface | hyperbolical |
| Total weight of the optical telescope | 12 t |

8. Support tripod

|  |  |  |
| --- | --- | --- |
| Length of the supports | | ≈ 27 m |
| Size of the cross section of the supports | | 1.2 х 0.8 m |
| Weight of each support | | 12 t |
| Load on the supports | on the southern | 70 t |
| on the eastern and western | each 30 t |
| Diameter of the ring bearer | | 6 m |
| Weight of the bearer | | 20 t |
| Weight of the turning frame | | 7.5 t |
| Total length of the turning structure | | 30 m |
| Total weight of the counterweights of the small radio reflector | | 6 t |
| Total weight of the turning structure together with the small radio reflector and optical telescope | | 70 t |
| Total weight of the support tripod with the turning system | | 130 t |

9. Settings

|  |  |  |  |
| --- | --- | --- | --- |
| Panels of the main radio reflector | Number of regulating bolts on each panel | | 4 |
| Limits of adjustments (course) | | ±25 mm |
| Pitch ( 10˚ turn of the screw) | | 14 mcm |
| Panels of the small reflector | Number of regulating bolts on each panel | | 4 |
| Limits of adjustments (course) | | ±15 mm |
| Pitch ( 10˚ turn of the screw) | | 14 mcm |
| Support tripod  (3 mechanisms) | | Limits of the manual regulation of the leg length | ±250 mm |
| Pitch of the screw | 10 mm |
| Limits of the automated regulation of the leg length | | Pitch ( 1 turn of the motor ) | 0.5 mm |
| Accuracy of auto stabilization of the lengths of the legs | 20 mcm |
| Hanger of the small reflector (3 mechanisms) | | Limits of the length regulation | ±60 mm |
| Step ( 1 step of the step motor ) | 10 mcm |
| Limits of regulation of the angular position | ±6˚ |
| Step ( 1 step of the step motor ) | 10˝ |
| Mechanisms of radio-focus | | Limits of travel in the X and Y axes | ±75 mm |
| Step ( 1 step of the step motor ) | 10 mcm |
| Limits of travel in the Z axis | ±50 mm |
| Step ( 1 step of the step motor ) | 10 mcm |
| Limits of turning round the axis Z | 360˚ |
| Turning step | 1˚ |
| Mechanisms of optical focus | | Limits of travel in the X and Y axes | ±35 mm |
| Step ( 1 step of the step motor ) | 10 mcm |
| Limits of travel in the Z axis | ±50 mm |
| Step ( 1 step of the step motor ) | 10 mcm |
| Limits of turning round the axis Z | 360˚ |
| Turning step | 1˚ |

10. Automatic control system

|  |  |  |  |
| --- | --- | --- | --- |
| Error of guidance and support | | | 1˝- 3˝ |
| Total number of electric drives | | | 28 |
| Including: | digital | | 4 |
| laser | | 9 |
| servo- systems | | 7 |
| Number of digital sensors angle-code | | | 4 |
| Error of sensors angle-code | | | 2˝ |
| Number of control panels | | | 3 |
| Number of observation panels | | | 2 |
| The central control unit carries out in the manual and automatic (computer) modes: | | guidance, support, scanning, applications, adjustments, control and indication, communication | |
| Control panel Radio-1 carries out: | | scanning, adjustments, control and indication, control of servicing systems | |
| Control panel Optica-1 carries out: | | fine correction, adjustments, control and indication, control of servicing systems | |
| Observation panels Radio-2 and Optica-2 carry out: | | registration of signals, indication, selection of the signal processing modes in the computer, control | |

11. Radio receiving equipment

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Radiometers of ROT | Wave length, mm/ Frequency, GHz | | | | | |
| 2/138 | 3/94 | 8/34 | 30/10 | 100/3 | 200/1.5 |
| Self-noise, К | 6400 | 1900 | 2300 | 100 | 260 | 200 |
| Sensitivity К (at =1 sec, Тш =300К) | 0.3 | 0.1 | 0.06 | 0.02 | 0.16 | 0.2 |
| Free transmission range, MHz | 1000 | 1000 | 3800 | 800 | 25 | 14 |
| Path length to the focus, mm | 164 | 241 | 221 | 250 | 250 | 250 |
| Stream sensitivity, (W/m2\*Hz)\*10-27  (at Seff=500 m2) | 16.5 | 5.5 | 3.3 | 1.1 | 8.8 | 11 |
| Nonlinearity in the dynamic range 25 dB, dB | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Input VSWR | 1.3 | 1.2 | 1.15 | 1.1 | 1.1 | 1.1 |

These conventional, uncooled radiometers were manufactured in the All-union Scientific Research Institute of Radio-physical measurements under the leadership of Paris Herouni.

12. Storage of time

|  |  |
| --- | --- |
| Frequency and time standard Ч1-69 |  |
| Nominal value of the output signal frequency | 5 MHz, 1 MHz, 100 kHz |
| Relative error of output signals by frequency within the limits | ±2\*10-11 |
| Relative systematic change in frequency in a day within the limits | ±1\*10-12 |

13. Servicing systems

|  |  |
| --- | --- |
| Underground pipe to drain water from the bowl: |  |
| diameter | 1m |
| length | 120m |
| Snow removing system: |  |
| number of heaters with fans (under the main reflector) | 60 |
| total power | 1 MW |
| average number of snowing days in a year | 20 |
| Number of lifts | 3 |
| Folding platform to the radio focus | 1 |
| List of other servicing systems: | lighting, washing of the main reflector, communication and messaging, cryogenics, measurements, control of covers of the optical telescope, photo guides, and cameras of optical focus, blinds, etc., waterworks, weather station, geodesic points, etc. |

14. The ranges of view and the time of observations

The critical aspect angle is determined by the touch-down of the used and geometric apertures. However, in practice, certain losses of the area (up to 10%) may be acceptable for the sake of increasing that angle. Calculations show that the increase of the critical angle in degrees is numerically equal to the approximate loss of the area in percentage terms.

The possibility of observing these or those celestial sources with the given tool is determined by the view ranges of the antenna, the width of the installation site φ, the source declination, the angle of the possible inclination of the tool towards the south on the whole from Zenith in the plane of the local meridian ψ.

The useful time of observation of the given source depends on the same factors, considering that it is not accepted to work at low dispositions of the source over the horizon as in the thick of the atmosphere with strong gradients, a substantial absorption of the signal and distortions because of the refraction take place. That is why, the sources are usually observed at angles 10-20˚ (and even 30˚) above the horizon.

The mentioned facts refer to both the radio-range and the optical range of the electromagnetic radiation.

In case of ROT-54/2.6, , i.e. there is an effective possibility for observing the sources with declinations from δ=-35˚to δ=+85˚. The sources located “lower” than the pole, towards the north horizon in the zone “inaccessible” to observation by ROT, after some time, rotating around the polar axis, will enter the zone of the ROT-54/2.6 observation themselves. Besides, having a gimbal, but not the azimuthal mounting system, ROT does not have a “dead” (“blind”) zone around the Zenith point as its axes look at the points on the horizon line, and these points are outside the observation zone.

The observation time for the sources with declinations from δ=-34˚ to δ=+84˚ ranges from 3 to 11 hours a day.

**The current state of the systems ROT-54/2.6**

Electro mechanics:

The state of the mechanical systems of the radio-telescope is satisfactory. It is necessary to maintain some irregularities in cardan system.

The accuracy of the surface of the small reflector has remained unchanged (RMS error = 60 mcm).

The accuracy of the panel surface of the antenna’s main radio-reflector and the accuracy of the reciprocal array of the panels have deteriorated, thus alignment and adjustment works are required.

The motors of the gimbal mounting system installed on the antenna operate normally. The small motion motors at the bases of the tripod legs, the radio-focus and optical focus corrections are in the working state.

Control systems:

Most electric drives, digital sensors, and servo-systems are out of order. All the control and observation panels need to be replaced. Many cables, connecting the units of the antenna with the controlling building are lacking.

The computer system needs to be updated. It is necessary to develop new software products.

Radio equipment:

At present, the radiometers are inoperative. In case of further application, it is necessary to reconstruct and repair the entire radio-receiving system.

Electronic digital acquisition system:

Digital acquisition system is lacking. There is a device of analogue acquisition (recorder).

Stabilization systems:

The ruby frequency standard is in an operating state. However, it is necessary to renew the cable system and to develop up-to-date transformation devices. The hydrogen standard is out of order.

Optical telescope:

The cables connecting the control systems of the reflector cover, video-guides, and the video-camera with the control board are lost.

Because of the impossibility of opening the telescope cover mechanically (it is opened only by an automatic command from the control board), it is not possible to estimate the surface of the reflector.

The cooler of the reflector is lacking.