Optical-Microwave Imager/Sounder MTVZA-OK of Spacecraft "Sich-1M"

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***Abstract* - The following paper describes the combined optical-microwave imager/sounder MTVZA-OK of spacecraft "Sich-1M" which is the joint Ukrainian and Russian project. The spacecraft has been launched On December 24, 2004.**

Keywords: microwave radiometer, imager, sounder, optical radiometer, remote sensing.

1. INTRODUCTION

MTVZA-OK will be used as the meteorological imaging/sounding system for remote sensing of ocean and land surface, as well as, for measuring global atmospheric temperature and water vapor profiles. The instrument is the next version of microwave imager/sounder MTVZA deployed on spacecraft "Meteor-3M" [1].

2. INSTRUMENT DESCRIPTION

MTVZA-OK combines both optical and microwave system deployed on a single scanning platform. Field of view (FOV) is common for optical and microwave imaging and sounding channels (Fig. 1). MTVZA-OK performance characteristics are given in Table 1.

2.1 Microwave System

The microwave radiometer MTVZA-OK is based on the technology of combining in space and time multifrequency and polarization measurements [1]. MTVZA-OK operating frequencies are located both in the transparent windows of atmosphere 6.9, 10.6, 18.7, 23.8, 31, 36.5, 42, 48, 89 GHz and absorbing lines of oxygen 52-57 GHz and water vapor 183.31 GHz. In addition, the MTVZA-OK includes some complementary non-typical operating frequencies especially for oceanographic research [2]. The instrument will provide measurements of atmosphere temperature profile to approximately 42 km and water vapor profile to 6 km.

All microwave radiometer channels are switched to single feed-horn antenna. The total-power radiometer configuration is employed. The channels of 6.9-48 GHz are the direct amplification radiometers. The channels of 52-57 GHz, 91 GHz and 183 GHz are built as superheterodyne receivers using balanced mixers. MTVZA-OK microwave performance and frequency channel characteristics are shown in Table 2.

The antenna system consists of an offset parabolic reflector of dimension 60 cm, illuminated by broad-band feed-horn antenna. To remain the invariant of viewing angle and polarization in scanning sector the reflector and feed-horn antenna are mounted on a scanning platform, containing the radiometers, digital data subsystem, power and signal transfer assembly, which rotates continuously about an axis parallel to the local spacecraft vertical. The power, commands, all data, timing and telemetry signals pass through slip ring connectors to the rotating assembly.

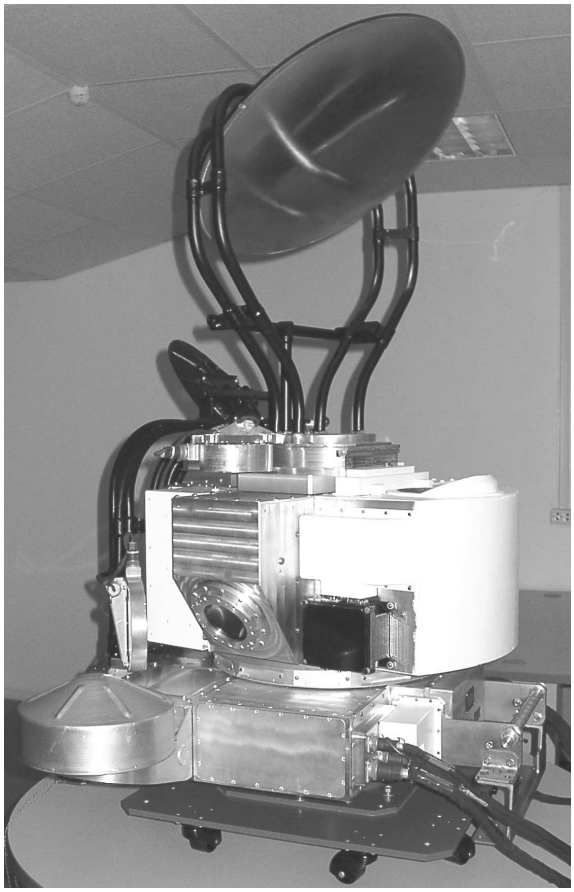

Fig 1. Optical-microwave imager/sounder MTVZA-OK.

The microwave calibration system consists of a small mirror and a hot reference absorber, which are not rotated with scanning platform. They are positioned off axis such that they pass between the feed-horn and the parabolic reflector, occulting the feed-horn once each scan. The mirror reflects cold 2.7 K cosmic background radiation into the feed-horn, thus serving, along with the hot reference absorber. This scheme provides an overall end-to-end absolute calibration, which includes the feed-horn.

2.2 Optical System

Optical system is a five channels radiometer providing four solar channels in the visible region and thermal infrared channel. All channel detectors are built on linear charge-coupled device. Four solar channels are built on silicon detector, thermal channel 3.55-3.93 micrometers is built on InSb detector. Thermal channel detector is cooled to 80 K by means of cryorefrigerator.

Standard deviation for instrumental noise signal referred to as the noise equivalent detected temperature (NEdT) is less than 0.2 K for background temperature 300K for a thermal channel. Four solar channels are characterized by signal-to-noise ratio as more than 8:1 for 0.5% albedo.

The thermal infrared calibration system consists of a flat mirror, reflecting cold cosmic background radiation into the objective lens, and a hot reference absorber. Calibration targets sample per scan.

TABLE 1
MTVZA-OK PERFORMANCE CHARACTERISTICS

System	Optical	Microwave
	Spectral Range (micrometers): 0.37-0.45 0.45-0.51 0.58-0.68 0.68-0.78 3.55-3.93	Frequencies (GHz): 6.9, 10.6 18.7, 23.8 31, 36.5 42, 48 52.3-57.0 91 183.31
Spatial Resolution (km)	1.1	19-260
Swath Width (km)	2000	
Conical Scanning Period (sec)	2.88	
Instability Scanning Period	10^{-4}	
Mass (kg)	120	
Power Consumed (W)	200	

TABLE 2.
MTVZA-OK MICROWAVE FREQUENCY CHANNEL CHARACTERISTICS

Channel No.	Center Frequency (GHz)	No. of pass bands	Band-width (MHz)	Effective FOV (kmxkm)	Imagery pixel (kmxkm)	Sensitivity (K/pixel)	Approximate peak sensitivity altitude (km)
1	6.9	1	350	112x260	38x38	0.3	-
2	10.6	1	100	76x177	38x38	0.5	-
3	18.7	1	200	45x104	38x38	0.4	-
4	23.8	1	400	36x86	38x38	0.3	-
5	31.5	1	1000	30x69	38x38	0.3	-
6	36.7	1	1000	26x60	38x38	0.3	-
7	42	1	1000	22x53	38x38	0.4	-
8	48	1	1000	21x47	38x38	0.4	-
9	52.80	1	400	18x43	38x38	0.4	2
10	53.30	1	400	18x43	38x38	0.4	4
11	53.80	1	400	18x43	38x38	0.4	6
12	54.64	1	400	18x43	38x38	0.4	10
13	55.63	1	400	18x43	38x38	0.4	14
14	57.290344±0.3222±0.1	4	50	18x43	57x57	0.4	20
15	57.290344±0.3222±0.05	4	20	18x43	57x57	0.7	25
16	57.290344±0.3222±0.025	4	10	18x43	57x57	0.9	29
17	57.290344±0.3222±0.01	4	5	18x43	57x57	1.3	35
18	57.290344±0.3222±0.005	4	3	18x43	57x57	1.7	42
19	91.65	2	2000	12x28	19x19	0.6	surface
20	183.31 ± 7.0	2	1500	8x19	38x38	0.5	1.5
21	183.31 ± 3.0	2	1000	8x19	38x38	0.6	2.9
22	183.31 ± 1.0	2	500	8x19	38x38	0.8	5.3

Channels 1-8, and 19 operate on both vertical and horizontal polarization, while other remaining channels operate on vertical polarization only.

3. SCANNING GEOMETRY

MTVZA-OK scanning geometry is shown in Fig. 2. The MTVZA-OK scanning platform rotates continuously about an axis parallel to the local spacecraft vertical with a period of 2.88 s during which the subsatellite point travels 19 km. The scan direction is from the right to the left when looking in the forward direction of the spacecraft, with the active scanning sector 120°, resulting in a swath width of 2000 km. The viewing angle is 55.4° and the incidence angle with respect to the Earth surface - 65°.

The sampling rate is 19x19 km for all microwave channels. To provide required sensitivity the size of imagery pixel differs depending on channels frequency (Table 2). The sampling rate is 1.1x1.1 km for all optical channels.

4. CONCLUSION

MTVZA-OK will provide some very interesting and powerful capabilities for complimentary studies of ocean-atmosphere system. By combining optical and microwave observations in the same instrument, some mutually beneficial advantages for determining geophysical parameters are obtained. Both atmospheric temperature profile and atmospheric humidity profile, sea surface temperature and near-surface wind speed, ocean color and processes of active ocean layer will be observed concurrently, enabling flow visualization and upwelling area to be better observed as well as estimates of ocean-atmosphere interaction. Uncertainties that often exist when multispectral and multifrequency observations are taken from different instruments looking through different parts of the atmosphere at different angles and different times are removed through the MTVZA-OK capabilities.

5. ACKNOWLEDGEMENT

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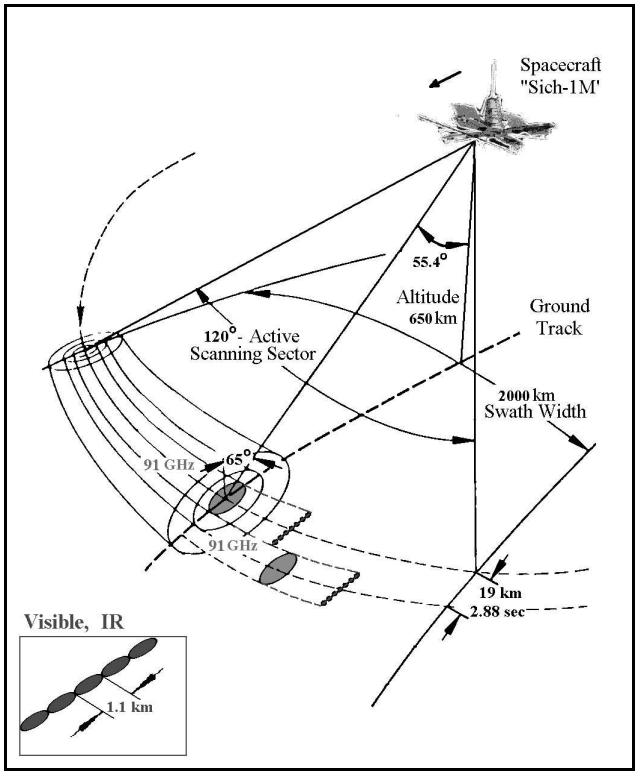

Fig. 2. MTVZA-OK scanning geometry.

6. REFERENCES

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