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| **Recommendation ITU-R RS.1861-1**  **(12/2021)** |
| **Typical technical and operational characteristics of Earth exploration-satellite service (passive) systems using allocations between 1.4 and 275 GHz** |
| **RS Series**  **Remote sensing systems** |

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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| Series of ITU-R Recommendations  (Also available online at <http://www.itu.int/publ/R-REC/en>) | |
| **Series** | Title |
| **BO** | Satellite delivery |
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| RS | Remote sensing systems |
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| **SF** | Frequency sharing and coordination between fixed-satellite and fixed service systems |
| **SM** | Spectrum management |
| **SNG** | Satellite news gathering |
| **TF** | Time signals and frequency standards emissions |
| **V** | Vocabulary and related subjects |

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| ***Note***: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.* |

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RECOMMENDATION ITU-R RS.1861-1[[1]](#footnote-1)\*

Typical technical and operational characteristics of Earth exploration-satellite service (passive) systems using allocations between 1.4 and 275 GHz

(Question [ITU-R 243/7](https://www.itu.int/pub/R-QUE-SG07.243))

(2010-2021)

Scope

This Recommendation provides typical technical and operational characteristics of Earth exploration-satellite service (passive) systems using allocations between 1.4 and 275 GHz for utilization in sharing studies.

Keywords

Earth exploration-satellite service, EESS (passive), remote sensing, conical scan, cross-track/nadir, push-broom, limb, interferometric, raster

Abbreviations/Glossary

AFOV Angular field of view

EESS Earth exploration-satellite service

IFOV Instantaneous field of view

NGSO Non-geostationary satellite orbit

NWP Numerical weather prediction

Related Recommendations and Reports

Recommendation ITU-R [RS.515](https://www.itu.int/rec/R-REC-RS.515/en) – Frequency bands and bandwidths used for satellite passive remote sensing

Recommendation ITU-R [RS.1813](https://www.itu.int/rec/R-REC-RS.1813/en) – Reference antenna pattern for passive sensors operating in the Earth exploration-satellite service (passive) to be used in compatibility analyses in the frequency range 1.4‑100 GHz

Recommendation ITU-R [RS.2017](https://www.itu.int/rec/R-REC-RS.2017/en) – Performance and interference criteria for satellite passive remote sensing

The ITU Radiocommunication Assembly,

*considering*

*a)* that Earth exploration-satellite service (EESS) (passive) observations may receive emissions from active services;

*b)* that there are exclusive EESS (passive) allocations in which all emissions are prohibited by RR No. **5.340**;

*c)* that EESS (passive) is allocated on a co-primary basis with active services in certain bands;

*d)* that studies considering protection for EESS (passive) systems are taking place within ITU‑R;

*e)* that in order to perform compatibility and sharing studies with EESS (passive) systems, the technical and operational characteristics of those systems must be known,

*recommends*

that the technical and operational parameters presented in Annex 1 of this Recommendation should be taken into account in studies considering EESS (passive) systems using allocations between 1.4 and 275 GHz.

Annex 1  
  
Typical technical and operational characteristics of Earth exploration-satellite service (passive) systems using allocations between 1.4 and 275 GHz

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# 1 Introduction

Passive sensors are used in the remote sensing of the Earth and its atmosphere by Earth exploration and meteorological satellites in certain frequency bands allocated to the Earth exploration-satellite service (EESS) (passive). The products of these passive sensor operations are used extensively in meteorology, climatology, and other disciplines for operational and scientific purposes. However, these sensors are sensitive to any emissions within their allocated band. Therefore, any RF emissions above a certain level may constitute interference to the passive sensors using those bands. In addition, it should be noted that passive sensors may not be able to differentiate the wanted signal from the interference and that interference may not be identifiable in the passive sensor products.

# 2 Current missions and predicted deployments

Several administrations and at least two recognized international organization operated more than 30 satellites in the EESS (passive) at the end of the year 2021. An additional two to three satellites are anticipated to be deployed per year for the foreseeable future. Individual satellites typically carry one to three passive sensing payloads operating below 275 GHz (some systems have also channels above 275 GHz, not specifically addressed in the present Recommendation). Each payload may conduct measurements simultaneously at three to tens of frequency channels as well as on two or more polarizations at a single channel. Additionally, hyperspectral passive microwave sensors can conduct measurements simultaneously in hundreds of frequency channels.

NOTE ‒ In the course of the first revision of this Recommendation, a number of sensors described in Recommendation ITU-R RS.1861-0 have been deleted. To avoid confusion in the future, their sensor designation (e.g. sensor A3) have not been reused. As a result, in some sections, the list of sensors do not follow a strict numerical order*.*

# 3 Typical orbits

Most of the EESS (passive) systems operate in non-geostationary satellite orbit (NGSO). Orbits are typically circular with an altitude between 350 and 1 400 km. Many EESS (passive) systems operate in a sun‑synchronous orbit. An area on the surface of the Earth may be observed by a NGSO satellite every day, although from different look angles on subsequent days. Observations with identical look angles may occur, but they are separated by orbital repeat cycles typically longer than two weeks.

In certain circumstances, multiple satellites operate in formation. Formation flying EESS satellites allow the capability to measure a portion of the atmosphere or surface of the Earth using both multiple instruments and multiple orientations. Measurements from multiple spacecraft will be separated within an amount of time shorter than the time constant of the phenomena being measured. Nominally this separation is on the order of 5 to 15 min, but can be as little as 15 s.

Two formations are used between multiple systems operating in NGSO. In one formation, two or more satellites directly follow each other performing measurements of the same parcel of atmosphere or the Earth’s surface as demonstrated by satellites A and B in Fig. 1. In the other formation, a nadir pointing passive sensor conducts a measurement while another spacecraft conducts a near-simultaneous measurement at the Earth’s limb as demonstrated by satellites A and C in Fig. 1.

Some of the EESS (passive) systems operate in geostationary satellite orbit (GSO).

# 4 Types of measurements

All EESS passive sensing systems perform a form of radiometry. Radiometry senses how much energy a body radiates based on its temperature. The amount of energy radiated from a perfect “blackbody” varies with frequency and is given by Planck’s equation. However, no substance is truly a perfect blackbody radiator and radiates different emission levels at different frequencies which conveys information regarding the observed substances. Frequencies of particular interest for EESS (passive) applications are provided in Recommendation ITU‑R RS.515.

Within a passive sensor’s field of view, there may be multiple radiators in *inter alia* atmosphere, water vapour, suspended ice particles, and cloud liquid water, emitting in the sensor’s bandwidth. Measurements not conducted on the Earth’s limb will also receive background emissions from water, soil, surface ice, or some combination of all three.

A single passive sensor cannot by itself identify how much energy is radiated by each substance in its field of view. For this reason, data products of most value are derived from measurements of multiple sensors operating at multiple frequencies. By performing radiometric measurements at multiple frequencies, the types of each natural emitter (e.g. water vapour, suspended ice, O3, etc.) and their concentrations may be derived. Any interference received by one sensor may corrupt the comparison result of multiple other sensor measurements.

FIGURE 1

Formation flying orientations

A diagram of a satellite

Description automatically generated with low confidence

## 4.1 Fixed-pointing, multiple frequency and polarization radiometric sensing

Sensing concurrently at multiple frequencies and polarizations offers the possibilities of identifying the presence of multiple natural emitters present in the field of view of the sensor as well as creating profiles of their concentrations. Profiling (a.k.a. sounding) sensors may be nadir-pointing or pointed at the limb of the Earth. Applications of profiling sensors includes the determination of atmospheric chemistry profiles of H2O, O3, ClO, BrO, HCl, OH, HO2, HNO3, HCN, and N2O through limb measurements.

Fixed pointing radiometers are also used to determine path delay of the radar signals caused by atmospheric water vapour. This information is used to improve measurement resolution of altimeters.

Radiometers designed for the whole Earth viewing perform continuous, hemispheric microwave soundings of temperature and humidity profiles as well as rain mapping.

## 4.2 Conical scanning radiometers

Many of the passive microwave sensors designed for imaging the Earth’s surface features use a conical scan configuration. Scans are typically performed by rotating the antenna at an offset angle from the nadir direction which maintains a constant ground incidence angle along the entire scan-lines. This feature allows for the uniform interpretation of surface measurements since the footprints will remain constant in size, and also because the polarization characteristics of the signal have an angular dependence which in this case is kept constant. Conical scanning radiometers are used to monitor various water processes including precipitation, oceanic water vapour, cloud water, near-surface wind speed, sea surface temperature, soil moisture, snow cover, and sea ice parameters. They can also be used to provide information on the integrated column precipitation content, its area distribution, and its intensity. Conical scanning antennas gather information over wide areas as shown in Fig. 2.

FIGURE 2

Geometry of conical scan passive microwave radiometers

Diagram

Description automatically generated

## 4.3 Cross-track/nadir scanning radiometers

The cross-track/nadir scanning is typically performed across the surface of the Earth, perpendicular to the orbital path, as shown in Fig. 3. Cross-track/nadir scanning is performed by physically rotating a reflector 360° through the nadir direction. As the reflector is directed away from the surface of the Earth, sensor channels are still used as calibrations are performed by measuring the cosmic background (i.e. cold sky) in addition to a known ‘warm’ source on the spacecraft, as shown in Fig. 4.

Scanning radiometric measurements are performed over wide areas creating virtual maps of the parameter being measured. This data product determines the horizontal spatial variability of a parameter rather than measuring the parameters at specific points. As the sensor scans away from nadir, the incidence angle increases and thus the footprint size increases and becomes more elliptical. Scanning measurements are also typically performed at multiple frequencies and polarizations.

Typical applications of cross-track/nadir scanning radiometers include the measurement of temperature profiles in the upper atmosphere (especially the stratosphere) and to provide a cloud-filtering capability for tropospheric temperature observations. They also are used to provide daily global observations of temperature and moisture profiles at high temporal resolution, and to measure cloud liquid water content and provide qualitative estimates of precipitation rate.

FIGURE 3

Typical cross-track Earth scanning pattern

Diagram

Description automatically generated

FIGURE 4

Typical sensing scanning pattern over 360°

Chart, pie chart

Description automatically generated

## 4.4 Push-broom radiometers

A ‘push-broom’ (along track) sensor consists of a line of sensors arranged perpendicular to the flight direction of the spacecraft, as illustrated in Fig. 5. Different areas of the Earth’s surface are detected as the spacecraft flies forward. The push-broom is a purely static instrument with no moving parts. The major desirable feature of the push-broom is that all resolution elements in a scan line are acquired simultaneously, and not sequentially as with mechanically scanned sensors, enabling this type of sensor to significantly increase the achievable radiometric resolution. Push‑broom sensors can be used for a variety of applications, including temperature profiles measurements of the atmosphere, and soil moisture and ocean salinity measurements.

FIGURE 5

Typical push-broom radiometer configuration

A picture containing text

Description automatically generated

## 4.5 Limb scanning radiometers

Some of the limb sounding radiometers also perform elevation scanning of the Earth’s limb in order to cover the whole vertical range and improve the vertical resolution.

## 4.6 Interferometric radiometers

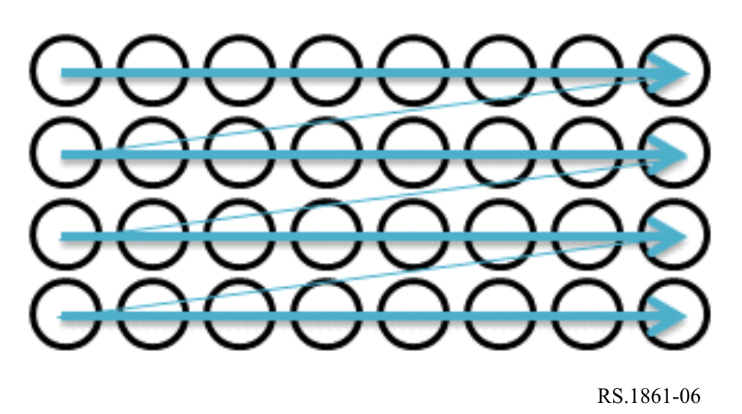
Unlike real aperture radiometers, interferometric radiometers use aperture synthesis technology to achieve brightness temperature measurements of the objective. Interferometric radiometers generally configure distributed small antenna elements to comprise a thinned array in order to reduce the complexity of antenna structure and in turn to deploy an antenna array with larger size to improve the spatial resolution. Because the spatial frequency distribution of brightness temperature is obtained by cross correlating the measurements from different two antenna elements, and then the brightness temperature image can be reconstructed from its spatial frequency distribution through Fourier transform, generally there is no need to scan mechanically for interferometric radiometers. But some interferometric systems also move or rotate their antenna elements to further reduce the number of elements.

## 4.7 Raster scanning radiometers

One of GSO sensors with real aperture antenna will use raster scan mode to achieve observations of the full Earth disk or a designated square region. In raster scanning, the beam sweeps horizontally left-to-right at a steady rate, then blanks and rapidly moves back to the left, where it turns back on and sweeps out the next line, as shown in Fig. 6. During this time, the vertical position is also steadily increasing (downward). GSO raster scanning radiometers can provide temperature and humidity profiles, cloud ice/liquid water columnar amount and gross profile, precipitation rate (particularly in cyclone or convection) with very high temporal resolution. Raster scanning radiometers are currently only identified in frequencies of 114.25 GHz and higher.

FIGURE 6

Typical raster scanning pattern



## 4.8 Wide strip and thin circle combined scanning radiometers

GSO radiometers also focus on rapidly changing weather phenomenon observation. It needs to use real aperture design to ensure the calibration accuracy and the observation reality of dynamic targets. The wide strip and thin circle combined scanning radiometer, as illustrated in Fig. 7(a) and (b), can realize calibration in every one second and scan on stable satellite platform in GSO. This scan mode combines the general scan (wide strip) of satellite and detail local scan (thin circle) of sensor.

As shown in Fig. 7, with the movement of the satellite, the large sensors on the satellite move alternately from west to east and from east to west, and step along the south direction. By this way, it forms the general scan in two dimensional stripes. At the same time, as shown the small black circles in Fig. 7, the small rotating scanning mirror inside the antenna scans quickly in a circle, in which total 110° angle range and the rest 250° are used for observation and calibration, and forms the detail local scan. As a result, the new beam scanning system with three-dimensional motion and two-dimensional coverage can solve the problem of large disturbance torque of the antenna motion, and also to meet the requirements of region coverage and time resolution. One step of the general scan and one circle of the detail local scan spend the same time. The main observation channels include oxygen absorption channel, water absorption channel and window channel.

FIGURE 7

Scanning pattern of real aperture radiometers

Graphical user interface

Description automatically generated

# 5 Definition of parameters

Table 1 provides the definitions of the technical and operational EESS parameters associated with passive sensors and their operation.

TABLE 1

Definitions of technical and operational EESS parameters for passive sensors

| Parameter | Definition |
| --- | --- |
| Sensor type | Various types of radiometers are possible depending on the technology of the radiometer: interferometric radiometer, fixed pointing, conical scan, nadir/cross-track scan, push-broom, limb scan radiometer |
| **Orbit parameters** | |
| Altitude | The height above the mean sea level |
| Inclination | Angle between the equator and the plane of the orbit |
| Eccentricity | The ratio of the distance between the foci of the (elliptical) orbit to the length of the major axis |
| Repeat period | The time for the footprint of the antenna beam to return to (approximately) the same geographic location |
| **Sensor antenna parameters**  Antenna characteristics vary among sensors. Measured antenna patterns are provided in § 6, where available. A reference radiation pattern is currently being developed for use in other cases | |
| Number of beams | The number of beams is the number of Instantaneous Field of View (IFOV) on Earth from which data are acquired at one time |
| Antenna size | For real aperture radiometers, it is the diameter of the antenna reflector;  For interferometric radiometers, it is the size of antenna array. |
| Maximum antenna gain | The maximum antenna gain can be the real one, or, if it is not known, it can be computed using the antenna efficiency  and *D* diameter of the reflector (when applicable), with the formula: |
| Polarization | Specification of linear (i.e. vertical, horizontal ,+45 º, −45º) or circular (i.e. left-hand, right-hand) polarization |
| −3 dB beamwidth | The −3 dB beamwidth, θ3dB, is defined as the angle between the two directions in which the radiation intensity is one-half the maximum value. This value provides a simple and general comparison of the width of the antenna’s main lobe.  For interferometric radiometers, it is the beamwidth of synthetic beam.  Note: The full antenna pattern is susceptible to interference and should be used in interference analyses. |

TABLE 1 (*cont.*)

| Parameter | Definition |
| --- | --- |
| Instantaneous field of view | The instantaneous field of view (IFOV) for a real aperture system is the area over which the detector is sensitive to radiation, generally defined as the linear dimensions of the beam on the Earth corresponding to the −3 dB beamwidth. By knowing the altitude of the satellite, the dimension of the IFOV can be calculated on the Earth’s surface at the boresight direction (or at the tangent point for limb sounding sensors): the IFOV is generally expressed in km × km representing the minor and major axis of the footprint. The area of the IFOV (in km²) is also provided. The IFOV is a measure of the size of the resolution element.  In a scanning system the IFOV refers to the solid angle subtended by the detector when the scanning motion is stopped. For conical scan radiometers, two values are usually computed:  – along-track: in the direction of the platform motion (along the in-track direction);  – cross-track: in the direction orthogonal to the motion of the sensor platform.  For nadir scan radiometers, such as that shown in Fig. 3, the nadir  IFOV = H×θ3dB, where *H* is the altitude of the satellite and θ3dB is the half-power beamwidth. The area of the nadir IFOV is  See also Fig. 8.  Since the direct measurements of interferometric radiometers are done in the spatial frequency domain, the IFOV parameter which usually describes the characteristic of spatial domain may not be applicable to interferometric radiometers. |
| Off-nadir pointing angle | The angle between the nadir and the pointing direction. It is the angle α in Fig. 8 |
| Incidence angle at Earth | The angle between the pointing direction and the normal to the Earth’s surface. It is the angle *i* as in Fig. 8 |
| Swath width/Coverage | The swath width is defined as the linear ground distance covered in the cross-track direction for NGSO radiometersor the angular field of view (AFOV), scanning angle. For a nadir radiometer, it depends on the maximum off nadir angle. The field of view (FOV) is the total range of viewing of a sensor into the direction of the target. The cross‑track component of the FOV is equivalent to the swath width.  GSO radiometers normally need to cover the full Earth disk or part of the disk. |
| Main beam efficiency | Note: This parameter is only included for the 10.6-10.7 GHz and 36-37 GHz bands due to its use in Resolution **751 (WRC-07)** and Resolution **752 (WRC-07)**,respectively. The main beam efficiency is defined as the ratio of the energy received in the main beam, which is 2.5 times the antenna’s −3 dB beamwidth, to the energy received in the complete antenna pattern. This parameter is not the same as the antenna efficiency. |
| Antenna efficiency | A measure of how effective an antenna is at receiving electromagnetic waves. The antenna efficiency is defined as the ratio of the maximum effective area of the antenna to the aperture area. This parameter is not the same as main beam efficiency. It is in particular used to compute the value of maximum antenna gain (see above) |
| Beam dynamics | The beam dynamics is defined as follows:  – For conical scans of NGSO systems, it is the rotating speed of the beam;  – For mechanical nadir scans of NGSO systems, it is the scan period, and the observation time in each scan period (i.e. the time of fulfilling one swath width scanning) may also be needed since the rotating speed of the antenna is commonly not constant;  – For NGSO interferometric radiometers, it may not be applicable.  – For GSO radiometers, it is the observation time of accomplishing a full disk scan or a special regional scan. |
| Sensor antenna pattern | Antenna gain as a function of off-axis angle. For interferometric radiometers, it is the pattern of synthetic beam. |

TABLE 1 (*end*)

| Parameter | Definition |
| --- | --- |
| Cold calibration antenna gain | Antenna gain in the direction of (cold) space. This could be the maximum gain of the primary antenna or the secondary antenna |
| Cold calibration horizontal angle | Horizontal angle (degrees relative to satellite track) of the cold calibration measurement. This angle is measured in the tangent plane relative to the along-track direction |
| Cold calibration vertical angle | Vertical angle (degrees relative to nadir direction) of the cold calibration measurement. This angle is measured out from the tangent plane |
| **Sensor receiver parameters** | |
| Sensor integration time | The *sensor integration time* corresponds to the short period of time allocated for the radiative measurement of the instantaneous area of observation by the detector of a sensor |
| Channel bandwidth | The *channel bandwidth* is the range of frequencies around a centre frequency used by the passive sensor |
| **Measurement spatial resolution** | |
| Horizontal resolution | The *spatial resolution* is often defined as the ability to distinguish between two closely spaced objects on an image. It is generally expressed in both horizontal (usually cross-track direction) and vertical (along-track direction) resolutions. (Note that “vertical”, in this sense, does not refer to altitude.) For limb sounding sensors, horizontal resolution is in the direction parallel with the surface, and vertical resolution is in the altitude direction.  There may be some difference between the spatial resolution and the IFOV size for one radiometer depending on its integration time and the moving speeds of its antenna and the platform. |
| Vertical resolution |

FIGURE 8

Scanning configuration

Diagram

Description automatically generated

Note that the field of view’s projection on the Earth’s surface becomes elliptical due to the increased incidence angle from nadir to the edge of the swath width (half swath).

# 6 Parameters of typical systems

This section provides typical parameters of passive sensors for EESS (passive) bands between 1 GHz and 275 GHz. Table 2 lists the EESS (passive) bands and the section in this text that contains the passive sensor parameters for each frequency band. A consistent set of parameters is used for each band to support worst-case static analyses and dynamic analyses to determine interference levels into passive sensors.

TABLE 2

List of EESS (passive) bands

| EESS (passive) band | Section containing passive  sensor parameters |
| --- | --- |
| 1 400-1 427 MHz | 6.1 |
| 6 425-7 250 MHz | 6.2 |
| 10.6-10.7 GHz | 6.3 |
| 18.6-18.8 GHz | 6.4 |
| 21.2-21.4 GHz | 6.5 |
| 22.21-22.5 GHz | 6.6 |
| 23.6-24 GHz | 6.7 |
| 31.3-31.8 GHz | 6.8 |
| 36-37 GHz | 6.9 |
| 50.2-50.4 GHz | 6.10 |
| 52.6-54.25 GHz | 6.11 |
| 54.25-59.3 GHz | 6.12 |
| 86-92 GHz | 6.13 |
| 114.25-122.25 GHz | 6.14 |
| 148.5-151.5 GHz | 6.15 |
| 155.5-158.5 GHz | 6.16 |
| 164-167 GHz | 6.17 |
| 174.8-191.8 GHz | 6.18 |
| 200-209 GHz | 6.19 |
| 226-252 GHz | 6.20 |

## 6.1 Typical parameters of passive sensors operating in the 1 400-1 427 MHz frequency band

Frequencies near 1 400 MHz are ideal for measuring soil moisture, and also for measuring sea surface salinity and vegetation biomass. Soil moisture is a key variable in the hydrologic cycle with significant influence on evaporation, infiltration and runoff. In the vadose zone[[2]](#footnote-2), soil moisture governs the rate of water uptake by vegetation. Sea surface salinity has an influence on deep thermohaline circulation and the meridional heat transport. Variations in salinity influence the near surface dynamics of tropical oceans. To date, there is no capability to globally measure soil moisture and sea surface salinity directly from in-situ measurements, so the protection of this passive frequency band is essential for obtaining measurements on a global basis.

Some of the remote sensing missions operating in this band collect soil moisture data in the entire passive microwave band. Others missions use this frequency band collect measurements of ocean salinity with the goal of observing and modelling the processes that relate sea surface salinity variations to climatic changes in the hydrologic cycle, and to understand how these variations influence the general ocean circulation. Still other missions will use a different technological approach and will measure both soil moisture and ocean salinity.

Table 3 provides the characteristics and parameters of sensors on these missions.

TABLE 3

EESS (passive) sensor characteristics in the 1 400-1 427 MHz frequency band

|  | Sensor A1 | Sensor A2 | Sensor A4 |
| --- | --- | --- | --- |
| Sensor type | Interferometric radiometer | Conical scan | Conical scan |
| **Orbit parameters** | | | |
| Altitude (km) | 757 | 670 | 820 |
| Inclination (degree) | 98 | 98 | 98.702 |
| Eccentricity | 0 | 0 | 0.0011441 |
| Repeat period (days) | 3 | 3 | 29 |
| **Sensor antenna parameters** | | | |
| Number of beams | 1 | 1 | 1 |
| Antenna size | N/A | 6.2 m | 7.4 m |
| Maximum beam gain (dBi) | 9 | 37 | 39.1 |
| Polarization | V, H | V, H | V, H |
| −3 dB beamwidth (degree) | 71.6 | 2.6 | 1.89-2.20 |
| Instantaneous field of view | 756 km2 | 50.1 × 38.5 km | 77 × 43 km |
| Off-nadir pointing angle (degree) | 25 | 35.5 | 46.5 |
| Incidence angle at Earth (degree) | 2°/48 | 39.9 | 55 |
| Swath width (km) | 1 000 | 1 000 | >1 900 |
| Antenna efficiency |  | 0.60 |  |
| Beam dynamics | Fixed | 14.6 rpm | 7.8 rpm |
| Sensor antenna pattern | Fig. 9 | Fig. 10 |  |
| Cold calibration antenna gain (dBi) | N/A | N/A | 39.1 |
| Cold calibration angle (degrees re. satellite track) | N/A | N/A | 0 º |
| Cold calibration angle (degrees re. nadir direction) | N/A | N/A | 45º-180º |
| **Sensor receiver parameters** | | | |
| Sensor integration time | 1.2 s | 84 ms | 55.4 ms |
| Channel bandwidth (MHz) | 27 | 27 | 27 |
| **Measurement spatial resolution** | | | |
| Horizontal resolution (km) | 40 | 39 | 77 |
| Vertical resolution | N/A | N/A | 43 km |

FIGURE 9

**Sensor A1 antenna pattern for the 1 400-1 427 MHz frequency band**

Chart, line chart

Description automatically generated

FIGURE 10

**Sensor A2 antenna patterns for the 1 400-1 427 MHz frequency band**

Chart

Description automatically generated

## 6.2 Typical parameters of passive sensors operating in the 6 425-7 250 MHz frequency band

The 6-7 GHz frequency band channel is essential for observing global soil moisture, global sea surface temperature, temperature of sea ice and sea surface wind through cloud, in combination with other channels.

In measurement of soil moisture, measurement in higher frequencies is strongly influenced by vegetation and the atmosphere, and the 6-7 GHz frequency band is the most suitable for obtaining relatively higher spatial resolution measurements. In the case of measurement of sea surface temperature, measurement in higher frequencies is strongly influenced by the atmosphere and lower temperature is more difficult to measure in higher frequencies. This combination of effects makes the 6-7 GHz frequency band the most suitable for obtaining sea surface temperature.

Table 4 summarizes the parameters of passive sensors that are or will be operating in the 6.425‑7.25 GHz frequency band.

TABLE 4

EESS (passive) sensor characteristics in the 6 425-7 250 MHz frequency band

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor B3 | Sensor B4 | Sensor B5 | Sensor B6 | Sensor B7 |
| Sensor type | Conical scan | Conical scan | Conical scan | Conical scan | Conical scan |
| **Orbit parameters** | | | | | |
| Altitude (km) | 830 | 699.6 | 820 | 970 | 665.96 |
| Inclination (degree) | 98.85 | 98.186 | 98.702 | 99.3 | 98.06 |
| Eccentricity | 0 | 0.002 | 0.0011441 | 0.00117 | 0.0015 |
| Repeat period (days) |  | 16 | 29 | 14 | 3 |
| **Sensor antenna parameters** | | | | | |
| Number of beams | 1 | 1 | 4 | 1 | 1 |
| Antenna size (m) | 1.0 | 2.0 | 7.4 | 1.0 | 2.0 |
| Maximum beam gain | 35.5 dBi | 40.6 dBi | 51.5 dBi | 36 dBi | 40.6 dB |
| Polarization | V, H | V, H | V, H | V, H | V, H |
| −3 dB beamwidth (degree) | 2.5 | 1.8 | 0.43-0.58 | 3.11 | 1.8 |
| Instantaneous field of view (km) | 70 × 167 | 35 × 62 | 19 × 11 | 74 × 122 | 33 × 57 |
| Off-nadir pointing angle | 53.3° | 47.5° | 46.5° | 44° | 47.7° |
| Incidence angle at Earth | 65° | 55° | 55° | 53° | 55° |
| Swath width (km) | 2 200 | 1 450 | >1 900 | 1 700 | 1 535 |
| Antenna efficiency |  | 0.57 |  | 0.6 | 0.57 |
| Beam dynamics | 2.5 s/scan period, counter clockwise | 40 rpm | 7.8 rpm | 3.57 s/scan | 40 rpm |
| Sensor antenna pattern | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 |  | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 |
| Cold calibration antenna gain | 22.3 dBi | 25.6 dBi | 51.5 dBi | 25 dB | 25.6 dBi |

TABLE 4 (*end*)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor B3 | Sensor B4 | Sensor B5 | Sensor B6 | Sensor B7 |
| Cold calibration angle (degrees re. satellite track) | 315º | 115.5º | 0 º | 158° | 118.7º |
| Cold calibration angle (degrees re. nadir direction) | 90º | 97.0º | 45º-180º | 80 ° | 94.6º |
| **Sensor receiver parameters** | | | | | |
| Sensor integration time | 5 ms | 2.6 ms | 13.7 ms | 10 ms | 2.5ms |
| Channel bandwidth | 350 MHz centred at 6.925 GHz and at 7.3 GHz | 350 MHz centred at 6.925 GHz and at 7.3 GHz | 400 MHz centred at 6.925 GHz | 350 MHz | 350 MHz centred at 6.925 GHz and at 7.3 GHz |
| **Measurement spatial resolution** |  |  |  | 95 km |  |
| Horizontal resolution (km) | 32 | 35 | 19 | 122 | 33 |
| Vertical resolution (km) | 32 | 62 | 11 | 74 | 57 |

## 6.3 Typical parameters of passive sensors operating in the 10.6-10.7 GHz frequency band

The 10.6-10.7 GHz frequency band is of primary interest to measure rain, snow, sea state, and ocean wind. Tables 5 and 6 summarizes the parameters of passive sensors that are or will be operating in the 10.6‑10.7 GHz frequency band.

TABLE 5

EESS (passive) sensor characteristics in the 10.6-10.7 GHz frequency band

|  | Sensor C1 | Sensor C4 | Sensor C5 | **Sensor C6** |
| --- | --- | --- | --- | --- |
| Sensor type | Conical scan | Conical scan | Conical scan | Conical scan |
| **Orbit parameters** | | | | |
| Altitude (km) | 817 | 835 | 699.6 | 830 |
| Inclination (degree) | 98 | 98.85 | 98.186 | 98.85 |
| Eccentricity | 0 | 0 | 0.002 | 0 |
| Repeat period |  |  | 16 days |  |
| **Sensor antenna parameters** | | | | |
| Number of beams | 1 | 1 | 1 | 1 |
| Antenna size (m) | 0.9 | 0.65 | 2.0 | 1.0 |
| Maximum beam gain (dBi) | 36 | 33,7 | 44.1 | 38.7 |
| Polarization | H, V | H, V | H, V | H, V |
| −3 dB beamwidth (degree) | 2.66 | 2.9 | 1.2 | 2.0 |
| Instantaneous field of view (km) | 56 × 30 | 82 × 196 | 42 × 24 | 56 × 133 |
| Off-nadir pointing angle (degree) | 44.3 | 53.3 | 47.5 | 53.3 |
| Incidence angle at Earth (degree) | 52 | 65 | 55 | 65 |
| Swath width (km) | 1 594 | 1 600 | 1 450 | 2 200 |
| Main beam efficiency (1) |  |  | 93% |  |

TABLE 5 (*end*)

|  | Sensor C1 | Sensor C4 | Sensor C5 | **Sensor C6** |
| --- | --- | --- | --- | --- |
| Antenna efficiency | 0.40 | 0.89 | 0.52 | 0.60 |
| Beam dynamics | 20 rpm | 2.5 s/scan period, clockwise | 40 rpm | 2.5 s/scan period, counter clockwise |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain (dBi) | N/A | 25 | 29.6 | 25.5 |
| Cold calibration angle (degrees re. satellite track) | N/A | 315º | 115.5º | 315º |
| Cold calibration angle (degrees re. nadir direction) | N/A | 90º | 97.0º | 90º |
| **Sensor receiver parameters** | | | | |
| Sensor integration time (ms) | 1 | 5 | 2.6 | 5 |
| Channel bandwidth | 100 MHz | 100 MHz centred at 10.65 GHz | 100 MHz centred at 10.65 GHz | 100 MHz centred at 10.65 GHz |
| **Measurement spatial resolution** | | | | |
| Horizontal resolution (km) | 38 | 32 | 24 | 32 |
| Vertical resolution (km) | 38 | 32 | 42 | 32 |
| (1) This parameter is included for this band due to its use in Resolution **751 (WRC-07)**. | | | | |

TABLE 6

EESS (passive) sensor characteristics in the 10.6-10.7 GHz frequency band

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor C7 | Sensor C8 | Sensor C9 | Sensor C10 | Sensor C11 |
| Sensor type | Conical scan | Conical scan | Conical scan | Conical scan | Conical scan |
| **Orbit parameters** | | | | | |
| Altitude (km) | 407 | 820 | 407 | 970 | 665.96 |
| Inclination (degree) | 50° | 98.702° | 65° | 99.3° | 98.06° |
| Eccentricity | 0.003 | 0.0011441 | 0 | 0.00117 | 0.0015 |
| Repeat period (days) |  | 29 | 43.5 | 14 | 3 |
| **Sensor antenna parameters** | | | | | |
| Number of beams | 1 | 4 | 1 | 1 | 2 |
| Antenna size (m) | 1.1 | 7.4 | 1.22 | 1.0 | 2.0 |
| Maximum beam gain (dBi) | 39.6 | 50.5 | 40.6 | 37 | 44.1 |
| Polarization | H, V | H, V | H/V | V, H | H,V |
| −3 dB beamwidth (degree) | 1.6 | 0.50-0.74 | 1.72 | 2.36 | 1.2 |
| Instantaneous field of view (km) | 30 × 18 | 19 × 11 | 32.1 × 19.4 | 56 × 93 | 22 × 38 |
| Off-nadir pointing angle | 48.6° | 46.5° | 48.5° | 44° | 47.7° |
| Incidence angle at Earth | 53° | 55° | 52.8° | 53° | 55° |
| Swath width (km) | 800 | >1 900 | 921 | 1 700 | 1 535 |
| Main beam efficiency (1) |  |  | 91.1% | 97% | 93% |

TABLE 6 (*end*)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor C7 | Sensor C8 | Sensor C9 | Sensor C10 | Sensor C11 |
| Antenna efficiency | 0.606 |  |  | 0.6 | 0.59 |
| Beam dynamics | 30 rpm | 7.8 rpm | 32 rpm | 3.57 s | 40 rpm |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 |  | Rec. ITU-R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 |
| Cold calibration antenna gain (dBi) | 36.8 | 50.5 | 27.8 | 27 | 29.6 |
| Cold calibration angle (degrees re. satellite track) | 180° | 0 º | 206.7° (CCW) | 158° | 118.7º |
| Cold calibration angle (degrees re. nadir direction) | 90° | 45º-180º | 107.5° | 80° | 94.6º |
| **Sensor receiver parameters** | | | | | |
| Sensor integration time (ms) | 2.08 | 13.4 | 3.6 | 10 | 2.5 |
| Channel bandwidth | 100 MHz centred at 10.65 GHz | 100 MHz centred at 10.65 GHz | 100 MHz centred at 10.65 GHz | 100 MHz | 100 MHz centred at 10.65 GHz and 500 MHz centred at  10.25 GHz |
| **Measurement spatial resolution** |  |  |  | 72 km |  |
| Horizontal resolution (km) | 22.2 | 19 | 19.4 | 93 | 22 |
| Vertical resolution (km) | 29.9 | 11 | 32.1 | 56 | 38 |
| (1) This parameter is included for this band due to its use in Resolution **751 (WRC-07)**. | | | | | |

## 6.4 Typical parameters of passive sensors operating in the 18.6-18.8 GHz frequency band

The 18.6-18.8 GHz frequency band is essential for observing global rain rates, sea state, sea ice, water vapour, ocean wind speed, soil emissivity, and humidity. Tables 7 and 8 summarizes the parameters of passive sensors that are or will be operating in the 18.6‑18.8 GHz frequency band.

TABLE 7

EESS (passive) sensor characteristics in the 18.6-18.8 GHz frequency band

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor D3 | Sensor D4 | Sensor D5 | Sensor D6 | Sensor D7 |
| Sensor type | Conical scan | Conical scan | Conical scan | Conical scan | Conical scan |
| **Orbit parameters** | | | | | |
| Altitude (km) | 865.6 | 835 | 699.6 | 830 | 407 |
| Inclination (degree) | 20 | 98.85 | 98.186 | 98.85 | 50 |
| Eccentricity | 0 | 0 | 0.002 | 0 | 0.003 |
| Repeat period (days) | 7 |  | 16 |  |  |
| **Sensor antenna parameters** | | | | | |

TABLE 7 (*end*)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor D3 | Sensor D4 | Sensor D5 | Sensor D6 | Sensor D7 |
| Number of beams |  | 1 | 1 | 1 | 1 |
| Antenna size (m) | 0.65 | 0.65 | 2.0 | 1.0 | 1.1 |
| Maximum beam gain (dBi) |  | 38.7 | 49.4 | 43.6 | 44.4 |
| Polarization | V, H | V, H | V, H | V, H, V+45°, V-45° | V, H |
| −3 dB beamwidth (degree) | 0.67 | 1.9 | 0.65 | 1.2 | 1.0 |
| Instantaneous field of view (km) | 10 | 54 × 128 | 22 × 14 | 34 × 80 | 19 × 11 |
| Off-nadir pointing angle (degree) | 44.5 | 53.3 | 47.5 | 53.3 | 48.6 |
| Incidence angle at Earth (degree) | 52.3 | 65 | 55.0 | 65 | 53 |
| Swath width (km) |  | 1 600 | 1 450 | 2 200 | 800 |
| Antenna efficiency |  |  | 0.5679 | 0.5974 | 0.594 |
| Beam dynamics | 20 rpm | 2.5 s scan period, clockwise | 40 rpm | 2.5 s scan period, counter clockwise | 30 rpm |
| Sensor antenna pattern | Rec. ITU-R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 |
| Cold calibration antenna gain (dBi) | N/A | 30 | 33.9 | 30.7 | 41.4 |
| Cold calibration angle (degrees re. satellite track) | N/A | 315º | 115.5º | 315º | 180° |
| Cold calibration angle (degrees re. nadir direction) | N/A | 90º | 97.0º | 90º | 90° |
| **Sensor receiver parameters** | | | | | |
| Sensor integration time (ms) | N/A | 5 | 2.6 | 5 | 2.08 |
| Channel bandwidth | N/A | 200 MHz centred at 18.7 GHz | 200 MHz centred at 18.7 GHz | 200 MHz centred at 18.7 GHz | 200 MHz centred at 18.7 GHz |
| **Measurement spatial resolution** | | | | | |
| Horizontal resolution (km) | 40 | 32 | 14 | 32 | 15.4 |
| Vertical resolution (km) | 40 | 32 | 22 | 32 | 19 |

TABLE 8

EESS (passive) sensor characteristics in the 18.6-18.8 GHz frequency band

|  | Sensor D8 | Sensor D9 | Sensor D10 | Sensor D11 | Sensor D12 | Sensor D13 | Sensor D14 |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Conical scan | Conical scan | Nadir | Conical scan | Fixed-pointing | Conical scan | Conical scan |
| **Orbit parameters** | | | | | | | |
| Altitude (km) | 820 | 407 | 1 336  890.6 \* | 970 | 970 | 665.96 | 830 |
| Inclination (degree) | 98.702 | 65 | 66  77.6 \* | 99.3 | 99.3 | 98.06 | 98.7 |
| Eccentricity | 0.0011441 | 0 | 0 | 0.00117 | 0.00117 | 0.0015 | 0.001 |
| Repeat period (days) | 29 | 43.5 | 9.92  20.9 \* | 14 | 14 | 3 | 29 |
| **Sensor antenna parameters** | | | | | | | |
| Number of beams | 8 | 1 | 1  2\* | 1 | 3 | 1 | 1 |
| Antenna size (m) | 7.4 | 1.22 | effectively 0.61 m;  physical reflector is 1 m, but beam is intentionally de‑focused | 1.0 | 0.92 | 2.0 | 0.76 |
| Maximum beam gain (dBi) | 59.6 | 45.6 | 40.5 | 43 | 43 | 49.4 | 41.5 |
| Polarization | H, V | H/V | Dual Linear | V, H | V, H | V, H | V, H |
| −3 dB beamwidth (degree) | 0.17-0.21 | 0.98 | 1.6 | 1.29 | 1.25 | 0.65 | 1.65 |
| Instantaneous field of view (km) | 7 × 4 | 18.1 × 10.9 | 37 × 37  25 × 25 \* | 31 × 51 | 21.0 × 21.0 | 21 × 12 | 36 × 60  (1 703 km²) |
| Off-nadir pointing angle (degree) | 46.5 | 48.5 | 0  ±2.65° cross-track\* | 44 | −2.4 | 47.7 | 44.8 |
| Incidence angle at Earth (degree) | 55 | 52.8 | 0  3.0 \* | 53 | -2.4 | 55.0 | 52.8 |

TABLE 8 (*end*)

|  | Sensor D8 | Sensor D9 | Sensor D10 | Sensor D11 | Sensor D12 | Sensor D13 | Sensor D14 |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Swath width (km) | >1 900 | 921 | 37  25 \* | 1 700 | N/A | 1 535 | 1 700 |
| Antenna efficiency |  |  | 0.79 | 0.6 | 0.63 | 0.57 | 0.6 |
| Beam dynamics | 7.8 rpm | 32 rpm | N/A | 3.57 s | N/A | 40 rpm | 45 rpm  (1.33 s) |
| Sensor antenna pattern |  | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain | 59.6 dBi | 31.9 dBi | 24.4 dBi | 32 dB | 21.8 dB | 33.9 dB |  |
| Cold calibration angle (degrees re. satellite track) | 0 º | 206.7° (CCW) | 53.5o azimuth from velocity vector | 158° | 0° | 118.7º | 165.5° to 203° |
| Cold calibration angle (degrees re. nadir direction) | 45º-180º | 107.5° | 77.4o elevation angle from nadir | 80° | 90° | 94.6º |  |
| **Sensor receiver parameters** | | | | | | | |
| Sensor integration time (ms) | 5.0 | 3.6 | 62.5 | 10 | 200 | 2.5 | 1 to 8 |
| Channel bandwidth | 200 MHz centred at 18.7 GHz | 200 MHz centred at 18.7 GHz | 200 MHz centred at 18.7 GHz | 200 MHz | ±250 MHz | 200 MHz centred at 18.7 GHz | 200 MHz centred at 18.7 GHz |
| **Measurement spatial resolution** |  |  |  | 40 km | 21.0 km |  |  |
| Horizontal resolution (km) | 7 | 10.9 | 37  25 \* | 51 | 21.0 | 12 |  |
| Vertical resolution (km) | 4 | 18.1 | 37  25 \* | 31 | 21.0 | 21 |  |
| NOTE – \* indicates that a particular sensor is flown on different missions, with different orbit and sensor parameters. | | | | | | | |

## 

## 6.5 Typical parameters of passive sensors operating in the 21.2-21.4 GHz frequency band

The 21.2-21.4 GHz frequency band in addition to the 23.6-24 GHz frequency band are used for measurements of water vapour and liquid water both on the Earth’s surface and in the atmosphere. They are on either side of the 22.235 GHz water-vapour spectral line. Atmospheric measurements are used with oxygen, O2, temperature measurements to remove the effect of water vapour on temperature profiles. Table 9 summarizes the parameters of passive sensors that are or will be operating in the 21.2-21.4 GHz frequency band.

TABLE 9

EESS (passive) sensor characteristics in the 21.2-21.4 GHz frequency band

|  | Sensor E1 | Sensor E2 |
| --- | --- | --- |
| Sensor type | Mechanical nadir scan | Push-broom(1) |
| **Orbit parameters** | | |
| Altitude (km) | 833 | 850 |
| Inclination (degree) | 98.6 | 98 |
| Eccentricity | 0 |  |
| Repeat period (dayys) | 9 |  |
| **Sensor antenna parameters** | | |
| Number of beams | 1 beam; 30 earth fields per 8 s scan period | 90 |
| Antenna size (m) | 0.3 | 0.9 |
| Maximum beam gain (dBi) | 34.4 | 45 |
| Polarization | V | H, V |
| −3 dB beamwidth | 3.3° | 1.1° |
| Instantaneous field of view | Nadir FOV: 48.5 km Outer FOV: 149.1 × 79.4 km | 16 km × 2 282 km |
| Off-nadir pointing angle | ±48.33° cross-track |  |
| Swath width (km) | 2 343 | 2 282 |
| Antenna efficiency | 0.62 | 0.78 |
| Beam dynamics | 8 s scan period | N/A (beams are unchanging) |
| Sensor antenna pattern | −10 dBi back lobe gain | −12 dBi back lobe gain |
| Cold calibration ant. gain (dBi) | 34.4 | 35 |
| Cold calibration angle (degrees re. satellite track) | 90° | 90° |
| Cold calibration angle (degrees re. nadir direction) | 83° |  |
| Total FOV cross/along-track | Outer FOV: 149.1 × 79.4 km Nadir FOV: 48.5 km | 100/1.1° |
| **Sensor receiver parameters** |  |  |
| Sensor integration time (ms) | 158 | N/A |
| Channel bandwidth | 200 MHz centred at 21.3 GHz | N/A |

TABLE 9 (*end*)

|  | Sensor E1 | Sensor E2 |
| --- | --- | --- |
| **Measurement spatial resolution** |  |  |
| Horizontal resolution (km) | 45 | 16 |
| Vertical resolution (km) | N/A | 16 |
| (1) Push-broom is a concept that has not yet been implemented at this frequency. | | |

## 6.6 Typical parameters of passive sensors operating in the 22.21-22.5 GHz frequency band

Passive sensors use the 22.21-22.5 GHz frequency band to collect radiometric data on integrated water vapor content. One representative sensor is characterized in Table 10.

TABLE 10

EESS (passive) sensor characteristics in the 22.21-22.5 GHz frequency band

|  | Sensor R1 |
| --- | --- |
| Sensor type | Conical |
| **Orbit parameters** | |
| Altitude (km) | 833 |
| Inclination (degree | 98.6 |
| Eccentricity | 0 |
| Repeat period (days) | 25 |
| **Sensor antenna parameters** | |
| Number of beams | 1 |
| Antenna size (m) | 0.61 |
| Maximum beam gain (dBi) | 40.0 |
| Polarization | V |
| −3 dB beamwidth | 2.09° (max) |
| Instantaneous field of view | 46.5 × 73.6 (Footprint size due to 1 × 2 averaging) |
| Off-nadir pointing angle (degree) | 45 |
| Incidence angle at Earth (degree) | 53.1 |
| Swath width (km) | 1 707 |
| Antenna efficiency | 0.50 |
| Beam dynamics (s) | 1.9 |
| Sensor antenna pattern | See Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain | NA |
| Cold calibration angle (degrees re. satellite track) | NA |
| Cold calibration angle (degrees re. nadir direction) | NA |
| Total FOV cross/along-track | Effective field of view (EFOV): 44.8 km (along scan) × 73.6 km (90° to scan); 1 × 2 spatial averaging |

TABLE 10 (*end*)

|  | Sensor R1 |
| --- | --- |
| **Sensor receiver parameters** | |
| Sensor integration time | 4.22 ms (for a single {unaveraged} sample) |
| Channel bandwidth | 450 MHz (max) centred at 22.235 GHz |
| **Measurement spatial resolution** | |
| Horizontal resolution (km) | 73.6 |
| Vertical resolution (km) | 46.5 |

## 6.7 Typical parameters of passive sensors operating in the 23.6-24 GHz frequency band

In case of a sounder, passive measurements around frequencies 23.8 GHz (total water vapour content), 31.5 GHz (window channel) and 90 GHz (liquid water) provide auxiliary data which play a predominant role in the retrieval process of temperature measurements performed in the O2 absorption spectrum. These auxiliary measurements must have radiometric and geometric performances and availability criteria consistent with those of the temperature measurements. In case of a conical scanning radiometer, it is possible to measure horizontal water vapour distribution with other channels. The main characteristics of the sensors are given in Tables 11 and 12.

TABLE 11

EESS (passive) sensor characteristics in the 23.6-24 GHz frequency band

|  | Sensor F1 | | Sensor F4 | Sensor F5 | Sensor F6 | Sensor F7 | Sensor F8 | Sensor F9 | Sensor F10 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Conical scan | Mechanical nadir scan | | Mechanical nadir scan | Conical scan | Push-broom | Conical scan | Mechanical nadir scan | Conical scan |
| **Orbit parameters** | | | | | | | | | |
| Altitude (km) | 817 | 833 822 \* | | 824 | 835 | 850 | 699.6 | 830 | 830 |
| Inclination (degree) | 20 | 98.6 98.7 \* | | 98.7 | 98.85 | 98 | 98.186 | 98.7 | 98.7 |
| Eccentricity | 0 | 0 0.001 | | 0 | 0 | 0 | 0.002 | 0.001 | 0.001 |
| Repeat period (days) | 7 | 9 29 \* | | 9 |  |  | 16 | 29 | 29 |
| **Sensor antenna parameters** | | | | | | | | | |
| Number of beams | 1 | 30 earth fields per 8 s scan period | | 2 | 1 | 90 | 1 | 1 | 1 |
| Antenna size (m) | 0.6 | 0.3 0.274 \* | | 0.203 | 0.65 | 0.9 | 2.0 | 0.35 | 0.76 |
| Maximum beam gain (dBi) | 40 | 34.4 | | 30.4 | 40.8 | 45 | 48.5 | 37 | 41.5 |
| Polarization | H, V | V QV \* | | QV | H, V | H, V | H, V | QH | V, H |
| −3 dB beamwidth (degree) | 1. 81 | 3.3 | | 5.2 | 1.5 | 1.1 | 0.75 | 2.7 | 1.65 |

TABLE 11 (*cont.*)

|  | Sensor F1 | | Sensor F4 | Sensor F5 | Sensor F6 | Sensor F7 | Sensor F8 | Sensor F9 | Sensor F10 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Instantaneous field of view (km) | 63 × 38 | Nadir FOV: 48.5  Outer FOV: 149.1 × 79.4  147 × 79 \* | | Nadir FOV: 74.8  Outer FOV: 323.1 × 141.8 | 43 × 101 | 16 × 2 282 | 26 × 15 | Nadir FOV: 39  (1 202 km²) Outer FOV: 130 × 67  (6 769 km²) | 36 × 60  (1 703 km²) |
| Off-nadir pointing angle (degree) | 44.5 | ±48.33 cross-track | | ±52.725 cross-track | 53.3 |  | 47.5 | ±49.31 cross-track | 44.8 |
| Incidence angle at Earth (degree) | 52.3 | 0 (nadir) 57.5 \* | |  | 65 |  | 55 | 0 (nadir) 58.9 | 52.8 |
| Swath width (km) | 1 607 | 2 343 2 186 \* | | 2 503 | 1 600 | 2 282 | 1 450 | 2 220 | 1 700 |
| Antenna efficiency | 0.60 | 0.60 | | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |
| Beam dynamics | 31.9 rpm | 8 s scan period | | 8/3 s scan period cross-track; 96 earth fields per scan period | 2.5 s scan period, clockwise | 90 resolution elements/ line | 40 rpm | 2.254 s | 45 rpm  (1.33 s) |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 | Fig. 11 | | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | 12 dBi back lobe gain | Rec. ITU‑R RS.1813 | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 |
| Cold calibration ant. gain (dBi) | N/A | 34.4 | | 30.4 | 32 | 35 | 32.4 |  |  |
| Cold calibration angle (degrees re. satellite track) | N/A | 90° −90° ± 3.9° \* | | 0 | 315° | 90° | 115.5º | 78° to 83° | 165.5° to 203° |
| Cold calibration angle (degrees re. nadir direction) | N/A | 83° | | 82.175 | 90° | 83° | N/A |  |  |

TABLE 11 (*end*)

|  | Sensor F1 | | Sensor F4 | Sensor F5 | Sensor F6 | Sensor F7 | Sensor F8 | Sensor F9 | Sensor F10 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sensor receiver parameters** | | | | | | | | | |
| Sensor integration time (ms) | 1 | 158 | | 18 | 5 | N/A | 2.5 | 13.7 | 1 to 8 |
| Channel bandwidth (MHz) | 400 | 270 centred at 23.8 GHz | | 270 centred at 23.8 GHz | 400 centred at 23.8 GHz | N/A | 400 centred at 23.8 GHz | 270 centred at 23.8 GHz | 400 centred at 23.8 GHz |
| **Measurement spatial resolution** | | | | | | | | | |
| Horizontal resolution (km) | 40 | 45 48 \* | | 75 | 32 | 16 | 15 |  |  |
| Vertical resolution (km) | N/A | 45 48 \* | | 75 | 32 | 16 | 25 |  |  |
| NOTE – \* indicates that a particular sensor is flown on different missions, with different orbit and sensor parameters. | | | | | | | | | |

TABLE 12

EESS (passive) sensor characteristics in the 23.6-24 GHz frequency band

|  | Sensor F11 | Sensor F12 | Sensor F13 | Sensor F14 | Sensor F15 | Sensor F16 | Sensor F17 | Sensor F18 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Nadir | Nadir | Conical scan | Conical scan | Conical scan | Conical scan | Fixed-pointing | Conical scan |
| **Orbit parameters** | | | | | | | | |
| Altitude (km) | 1 336  890.6 \* | 814.5 | 830 | 407 | 407 | 970 | 970 | 665.96 |
| Inclination (degree) | 66  77.6 \* | XX | 98.85 | 50 | 65 | 99.3 | 99.3 | 98.06 |
| Eccentricity | 0 |  | 0 | 0.003 | 0 | 0.00117 | 0.00117 | 0.0015 |
| Repeat period (days) | 9.92  20.9 \* |  |  |  | 43.5 | 14 | 14 | 3 |
| **Sensor antenna parameters** | | | | | | | | |
| Number of beams | 1  2 \* | 1 | 1 | 1 | 1 | 1 | 3 | 1 |
| Antenna size (m) | effectively 0.61 m; physical reflector is 1 m,  but beam is intentionally de-focused | 0.6 | 1 | 1.1 | 1.22 | 1.0 | 0.92 | 2.0 |
| Maximum beam gain | 42.3 dBi | 41 dBi | 45.7 dBi | 46.5 dBi | 46.6 dBi | 45 dBi | 45 dB | 48.5 dBi |
| Polarization | Dual Linear |  | V,H | H, V | V | V | V, H | H, V |
| −3 dB beamwidth (degree) | 1.4 | 1.8 | 1 | 0.8 | 0.85 | 1.12 | 0.98 | 0.65 |

TABLE 12 (*cont.*)

|  | Sensor F11 | Sensor F12 | Sensor F13 | Sensor F14 | Sensor F15 | Sensor F16 | Sensor F17 | Sensor F18 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Instantaneous field of view (km) | 33 × 33  22 × 22 \* | 25  (495 km²) | 29 × 68  (1 557 km²) | 15 × 9 | 16.0 × 9.7 | 27 × 44 | 16.6 × 16.6 | 24 × 14 |
| Off-nadir pointing angle (degree) | 0  ±2.65 cross-track \* | 1.9  along-track | 53.3 | 48.6 | 48.5 | 44 | 2.2 | 47.7 |
| Incidence angle at Earth (degree) | 0  3.0\* | 2.1 | 65 | 53 | 52.8 | 53 | 2.2 | 55 |
| Swath width (km) | 33  22 \* |  | 2 200 | 800 | 921 | 1 700 | N/A | 1 535 |
| Antenna efficiency | 0.73 | 0.60 | 0.60 | 0.594 |  | 0.6 | 0.69 | 0.60 |
| Beam dynamics | N/A |  | 2.5 s scan period, counter clockwise | 30 rpm | 32 rpm | 3.57 s | N/A | 40 rpm |
| Sensor antenna pattern | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 |
| Cold calibration ant. gain | 26.1 dBi |  | 33 dBi | 43.5 dBi | 33.4 dBi | 34 dB | 21.9 dB | 32.4 dBi |
| Cold calibration angle (degrees re. satellite track) | 53.5° azimuth from velocity vector |  | 315° | 180° | 206.7° (CCW) | 158° | 0° | 118.7º |
| Cold calibration angle (degrees re. nadir direction) | 77.4° elevation angle from nadir |  | 90° | 90° | 107.5° | 80° | 90° | 94.6º |

TABLE 12 (*end*)

|  | Sensor F11 | Sensor F12 | Sensor F13 | Sensor F14 | Sensor F15 | Sensor F16 | Sensor F17 | Sensor F18 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sensor receiver parameters** | | | | | | | | |
| Sensor integration time (ms) | 62.5 |  | 5 | 2.08 | 3.6 | 10 | 200 | 2.5 |
| Channel bandwidth (MHz) | 400  centred at 23.8 GHz |  | 400 centred at 23.8 GHz | 400 centred at 23.8 GHz | 400 centred at 23.8 GHz | 400 | ±250 | 400 centred at 23.8 GHz |
| **Measurement spatial resolution** |  |  |  |  |  | 34 km | 16.6 km |  |
| Horizontal resolution (km) | 33  22 \* |  | 32 | 8.8 | 9.7 | 44 | 16.6 | 14 |
| Vertical resolution (km) | 33  22 \* |  | 32 | 15.0 | 16.0 | 27 | 16.6 | 24 |
| NOTE – \* indicates that a particular sensor is flown on different missions, with different orbit and sensor parameters. | | | | | | | | |

FIGURE 11

Sensor F4 antenna pattern (23.8 GHz)

Chart

Description automatically generated

## 6.8 Typical parameters of passive sensors operating in the 31.3-31.8 GHz frequency band

Passive measurements around frequencies 23.8 GHz (total water vapour content), 31.5 GHz (window channel) and 90 GHz (liquid water) provide auxiliary data which play a predominant role in the retrieval process of temperature measurements performed in the O2 absorption spectrum. These auxiliary measurements must have radiometric and geometric performances and availability criteria consistent with those of the temperature measurements.

This frequency band is one of the frequency bands used for close-to-nadir atmospheric sounding in conjunction with the frequency bands such as 23.8 GHz and 50.3 GHz for the characterization each layer of the Earth’s atmosphere. The 31.3-31.5 GHz frequency band will also be used in conjunction with the frequency band 31.5-31.8 GHz as a ‘split window’. This will allow a comparison of the measurements conducted in the two sub-bands to check the quality of the data. This will then allow using the full band when the quality is expected good to increase the sensitivity of the sensor.

Tables 13 and 14 summarize the parameters of passive sensors that are or will be operating in the 31.3‑31.8 GHz frequency band.

TABLE 13

EESS (passive) sensor characteristics in the 31.3-31.8 GHz frequency band

|  | Sensor G1 | Sensor G2 | Sensor G3 |
| --- | --- | --- | --- |
| Sensor type | Nadir scan | Nadir scan | Conical scan |
| **Orbit parameters** | | | |
| Altitude (km) | 833 822 \* | 824 | 835 |
| Inclination (degree) | 98.6 | 98.7 | 98.85 |
| Eccentricity | 0.001 | 0 | 0 |
| Repeat period (days) | 9 29 \* | 9 |  |

TABLE 13 (*end*)

|  | Sensor G1 | Sensor G2 | Sensor G3 |
| --- | --- | --- | --- |
| **Sensor antenna parameters** | | | |
| Number of beams | 30 earth fields per 8 s scan period | 2 | 1 |
| Antenna size (m) | 0.30 0.274 \* | 0.203 | 0.65 |
| Maximum beam gain (dBi) | 34.4 | 30.4 | 43.2 |
| Polarization | V QV \* | QV | H, V |
| −3 dB beamwidth (degree) | 3.3 | 5.2 | 1.1 |
| Instantaneous field of view | Nadir FOV: 48.5 km Outer FOV:  149.1 × 79.4 km 147 × 79 km\* | Nadir FOV: 74.8 km Outer FOV:  323.1.1 × 141.8 km | 31 km × 74 km |
| Off-nadir pointing angle (degree) | ±48.33 cross-track | ±52.725 cross-track | 53.3 |
| Incidence angle at Earth (degree) | 0 57.5 \* | 0 | 65 |
| Swath width (km) | 2 343  2 186 \* | 2 500 | 1 600 |
| Antenna efficiency | 0.60 | 0.60 | 0.60 |
| Beam dynamics | 8 s scan period | 8/3 s scan period cross-track; 96 earth fields per scan period | 2.5 s scan period, clockwise |
| Sensor antenna pattern | Rec. ITU‑R  RS.1813 | Rec. ITU‑R  RS.1813 | Rec. ITU‑R  RS.1813 |
| Cold calibration ant. gain (dBi) | 34.4 | 30.4 | 34 |
| Cold calibration angle (degrees re. satellite track) | 90 −90° ± 3.9°\* | 0 | 315 |
| Cold calibration angle (degrees re. nadir direction) | 83.33 | 82.175 | 90 |
| **Sensor receiver parameters** | | | |
| Sensor integration time (ms) | 158 | 18 | 5 |
| Channel bandwidth | 180 MHz centred at 31.4 GHz | 180 MHz centred at 31.4 GHz | 0.5 GHz |
| **Measurement spatial resolution** | | | |
| Horizontal resolution (km) | 44 48 \* | 75 | 32 |
| Vertical resolution (km) | 44 48 \* | 75 | 32 |

NOTE – \* indicates that a particular sensor is flown on different missions, with different orbit and sensor parameters.

TABLE 14

EESS (passive) sensor characteristics in the 31.3-31.8 GHz frequency band

|  | Sensor G4 | Sensor G5 | Sensor G6 |
| --- | --- | --- | --- |
| Sensor type | Mechanical nadir scan | Conical scan | Conical scan |
| **Orbit parameters** | | | |
| Altitude (km) | 830 | 830 | 830 |
| Inclination (degree) | 98.7 | 98.7 | 98.85 |
| Eccentricity | 0.001 | 0.001 | 0 |
| Repeat period (days) | 29 | 29 |  |
| **Sensor antenna parameters** | | | |
| Number of beams | 1 | 1 | 1 |
| Antenna size (m) | 0.35 | 0.76 | 1 |
| Maximum beam gain (dBi) | 38 | 45.7 | 48.2 |
| Polarization | QH | V,H | V,H |
| −3 dB beamwidth (degree) | 2.7 | 1 | 0.77 |
| Instantaneous field of view | Nadir FOV: 39 km  (1 202 km²) Outer FOV: 130 × 67 km  (6 769 km²) | 22 × 36 km  (625 km²) | 22 km ×  51 km  (875 km²) |
| Off-nadir pointing angle (degree) | ±49.31 cross-track | 44.8 | 53.3 |
| Incidence angle at Earth (degree) | 0 (nadir) 58.9 | 52.8 | 65 |
| Swath width (km) | 2 220 | 1 700 | 2 200 |
| Antenna efficiency | 0.60 | 0.60 | 0.61 |
| Beam dynamics | 2.254 s | 45 rpm (1.33 s) | 2.5 s scan period, counter clockwise |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain |  |  | 35 dBi |
| Cold calibration angle (degrees re. satellite track) | 78° to 83° | 165.5° to 203° | 315 |
| Cold calibration angle (degrees re. nadir direction) |  |  | 90 |
| **Sensor receiver parameters** | | | |
| Sensor integration time (ms) | 13.7 | 1 to 8 | 5 |
| Channel bandwidth | 180 MHz  centred at 31.4 GHz | 200 MHz  centred at 31.4 GHz | 1 GHz centred  at 31.5 GHz |
| **Measurement spatial resolution** | | | |
| Horizontal resolution (km) |  |  | 32 |
| Vertical resolution (km) |  |  | 32 |

## 6.9 Typical parameters of passive sensors operating in the 36-37 GHz frequency band

The 36-37 GHz frequency band is vital for the study of global water circulation, rain rates, snow, sea ice and clouds. Tables 15 and 16 summarize the parameters of passive sensors that are or will be operating in the 36‑37 GHz frequency band.

TABLE 15

EESS (passive) sensor characteristics in the 36-37 GHz frequency band

|  | Sensor H1 | Sensor H4 | Sensor H5 | Sensor H6 | Sensor H7 |
| --- | --- | --- | --- | --- | --- |
| Sensor type | Conical scan | Conical scan | Conical scan | Conical scan | Conical scan |
| **Orbit parameters** | | | | | |
| Altitude (km) | 865.6 | 835 | 699.6 | 830 | 407 |
| Inclination (degree) | 20 | 98.85° | 98.186° | 98.85° | 50° |
| Eccentricity | 0 | 0 | 0.002 | 0 | 0.003 |
| Repeat period (days) | 7 |  | 16 |  |  |
| **Sensor antenna parameters** | | | | | |
| Number of beams |  | 1 | 1 | 1 | 1 |
| Antenna size (m) | 0.65 | 0.65 | 2.0 | 1 | 1.1 |
| Maximum beam gain (dBi) | 45 | 44.5 | 54.8 | 49.4 | 50.3 |
| Polarization | H | H, V | H, V | H, V, V+45, V-45 | H, V |
| −3 dB beamwidth (degree) | 1.8 | 0.9 | 0.35 | 0.67 | 0.65 |
| Instantaneous field of view (km) | 62 × 38 | 26 × 61 | 12 × 7 | 19 × 45 | 12 × 7.3 |
| Off-nadir pointing angle (degree) | 44.5 | 53.3 | 47.5 | 53.3 | 48.6 |
| Incidence angle at Earth | 52.3° | 65° | 55° | 65° | 53 |
| Swath width (km) | 1 607 | 1 600 | 1 450 | 2 200 | 800 |
| Main beam efficiency (1) | 96% | 94% | 93% |  |  |
| Antenna efficiency | 0.60 | 0.76 | 0.52 | 0.60 | 0.606 |
| Beam dynamics | 31.9 rpm | 2.5 s scan period, clockwise | 40 rpm | 2.5 s scan period, counter clockwise | 30 rpm |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 |
| Cold calibration antenna gain (dBi) | N/A | 35.5 | 39.3 | 36.5 | 47.3 |
| Cold calibration angle (degrees re. satellite track) | N/A | 315° | 115.5º | 315° | 180 |
| Cold calibration angle (degrees re. nadir direction) | N/A | 90° | 97.0 | 90° | 90 |

TABLE 15 (*end*)

|  | Sensor H1 | Sensor H4 | Sensor H5 | Sensor H6 | Sensor H7 |
| --- | --- | --- | --- | --- | --- |
| **Sensor receiver parameters** | | | | | |
| Sensor integration time (ms) | 1 | 5 | 2.6 | 5 | 2.08 |
| Channel bandwidth | 1 GHz | 1 GHz centred at 36.5 GHz | 1 GHz centred at 36.5 GHz | 1 GHz centred at 36.5 GHz | 1 GHz centred at 36.5 GHz |
| **Measurement spatial resolution** | | | | | |
| Horizontal resolution (km) | 40 | 32 | 6.8 | 32 | 11.5 |
| Vertical resolution (km) | N/A | 32 | 12 | 32 | 12.2 |
| (1) This parameter is included for this band due to its use in Resolution **752 (WRC-07)**. | | | | | |

TABLE 16

EESS (passive) sensor characteristics in the 36-37 GHz frequency band

|  | Sensor H8 | Sensor H9 | Sensor H10 | Sensor H11 | Sensor H12 | Sensor H13 |
| --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Conical scan | Nadir | Conical scan | Conical scan | Fixed-pointing | Conical scan |
| **Orbit parameters** | | | | | | |
| Altitude (km) | 820 | 814.5 | 407 | 970 | 970 | 665.96 |
| Inclination (degree) | 98.702 | 98.65 | 65 | 99.3 | 99.3 | 98.06 |
| Eccentricity | 0.001 144 1 | 0.001 148 | 0 | 0.00117 | 0.00117 | 0.0015 |
| Repeat period (days) | 29 | 27 | 43.5 | 14 | 14 | 3 |
| **Sensor antenna parameters** | | | | | | |
| Number of beams | 8 | 1 | 1 | 1 | 3 | 1 |
| Antenna size (m) | 7.4 | 0.6 | 1.22 | 1.0 | 0.92 | 2.0 |
| Maximum beam gain | 59.6 dBi | 44 dBi | 47.3 dBi | 48 dBi | 49 dB | 54.8 dBi |
| Polarization | H, V | V | H/V | V, H | V, H | H, V |
| −3 dB beamwidth (degree) | 0.15-0.24 | 1.31 | 0.81 | 0.71 | 0.67 | 0.35 |
| Instantaneous field of view | 5 × 3 | 19 diameter | 15.6 × 9.4 | 17 × 28 | 11.3 ×11.3 | 11 × 6 |
| Off-nadir pointing angle (degree) | 46.5 | 1.8 | 48.5 | 44 | 0 | 47.7 |
| Incidence angle at Earth (degree) | 55 | 2 | 52.8 | 53 | 0 | 55 |
| Swath width (km) | >1 900 | N/A | 921 | 1 700 | N/A | 1 535 |
| Main beam efficiency (see Note below) |  |  |  | 96% | 95.5% | 93% |
| Antenna efficiency |  |  |  | 0.6 | 0.58 | 0.53 |
| Beam dynamics | 7.8 rpm | N/A | 32 rpm | 3.57 s | N/A | 40 rpm |
| Sensor antenna pattern |  | Fig 12 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 |

TABLE 16 (*end*)

|  | Sensor H8 | Sensor H9 | Sensor H10 | Sensor H11 | Sensor H12 | Sensor H13 |
| --- | --- | --- | --- | --- | --- | --- |
| Cold calibration antenna gain | 59.6 dBi | 26.08 dBi | 34.3 dBi | 38 dB | 21.9 dB | 39.2 dBi |
| Cold calibration angle (degrees re. satellite track) | 0º | Deep sky pointing for cold calibration through a dedicated horn | 206.7° (CCW) | 158° | 0° | 118.7º |
| Cold calibration angle (degrees re. nadir direction) | 45º-180º | Deep sky pointing for cold calibration through a dedicated horn | 107.5° | 80° | 90° | 94.6º |
| **Sensor receiver parameters** | | | | | | |
| Sensor integration time (ms) | 3.6 | 152.88 | 3.6 | 10 | 200 | 2.5 |
| Channel bandwidth | Minimum of 300 MHz centred at 36.5 GHz | 1 GHz centred at 36.5 GHz | 1 000 MHz centred at 36.5 GHz | 1 000 MHz | ±500 MHz | 840 MHz centred at 36.42 GHz |
| **Measurement spatial resolution** |  |  |  | 22 km | 11.3 km |  |
| Horizontal resolution (km) | 5 | 19 | 9.4 | 28 | 11.3 | 6 |
| Vertical resolution (km) | 3 | 19 | 15.6 | 17 | 11.3 | 11 |

NOTE – This parameter is included for this band due to its use in Resolution **752 (WRC-07)**.

FIGURE 12

Sensor H9 antenna pattern (36.5 GHz)

Chart, bar chart, histogram

Description automatically generated

## 6.10 Typical parameters of passive sensors operating in the 50.2-50.4 GHz frequency band

This frequency band is one of several frequency bands between 50 GHz and 60 GHz that are used collectively to provide three-dimensional temperature profiles of the atmosphere. Tables 17 and 18 summarize the parameters of passive sensors that are or will be operating in the 50.2‑50.4 GHz frequency band.

TABLE 17

EESS (passive) sensor characteristics in the 50.2-50.4 GHz frequency band

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor I2 | Sensor I3 | Sensor I4 | Sensor I5 | Sensor I6 |
| Sensor type | Mechanical nadir scan | Push-broom | Mechanical nadir scan | Mechanical nadir scan | Conical scan |
| **Orbit parameters** | | | | | |
| Altitude (km) | 833 822 \* | 850 | 824 | 830 | 830 |
| Inclination (degree) | 98.6 98.7 \* | 98 | 98.7 | 98.7 | 98.7 |
| Eccentricity | 0 0.001 \* | 0 | 0 | 0.001 | 0.001 |
| Repeat period (days) | 9 29 \* |  | 9 | 29 | 29 |
| **Sensor antenna parameters** | | | | | |
| Number of beams | 30 earth fields per 8 s scan period | 90 | 2 | 1 | 1 |
| Antenna size (m) | 0.15 | 0.5 | 0.203 | 0.35 | 0.76 |
| Maximum beam gain (dBi) | 34.4 | 45 | 37.9 | 42 | 46.4 |
| Polarization | V QV \* | H, V | QH | QH | V, H |

TABLE 17 (*end*)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor I2 | Sensor I3 | Sensor I4 | Sensor I5 | Sensor I6 |
| −3 dB beamwidth (degree) | 3.3 | 1.1 | 2.2 | 1.4 | 1 |
| Instantaneous field of view (km) | Nadir FOV: 48.5  Outer FOV: 149.1 × 79.4  147 × 79 \* | 16 km × 2 282 km | Nadir FOV: 31.6 km Outer FOV: 136.7 × 60 | Nadir FOV: 20  (323 km²) Outer FOV:  67 × 35  (1 816 km²) | 22 × 36  (625 km²) |
| Off-nadir pointing angle (degree) | ±48.33 cross-track |  | ±52.725 cross-track | ±49.31 cross-track | 44.8 |
| Incidence angle at Earth (degree) | 57.5 |  |  | 0 (nadir) 58.9 | 52.8 |
| Swath width (km) | 2 343 2 186 | 2 282 | 2 500 | 2 220 | 1 700 |
| Antenna efficiency | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |
| Beam dynamics | 8 s scan period | 90 resolution elements per swath | 8/3 s scan period cross-track; 96 earth fields per scan period | 2.254 s | 45 rpm (1.33 s) |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) |
| Cold calibration antenna gain (dBi) | 34.4 | 35 | 37.9 |  |  |
| Cold calibration angle (degrees re. satellite track) | 90 −90° ± 3.9° \* | 90 | 0 | 78° to 83° | 165.5° to 203° |
| Cold calibration angle (degrees re. nadir direction) | 83.33 | 83 | 82.175 |  |  |
| **Sensor receiver parameters** | | | | | |
| Sensor integration time (ms) | 165 | N/A | 18 | 13.7 | 1 to 8 |
| Channel bandwidth (MHz) | 180 centred at 50.3 GHz | N/A | 180  centred at 50.3 GHz | 180 centred at 50.3 GHz | 180 centred at 50.3 GHz |
| **Measurement spatial resolution** | | | | | |
| Horizontal resolution (km) | 48 | 16 | 32 |  |  |
| Vertical resolution (km) | 48 | 16 | 32 |  |  |
| NOTE – \* indicates that a particular sensor is flown on different missions, with different orbit and sensor parameters. | | | | | |

TABLE 18

EESS (passive) sensor characteristics in the 50.2-50.4 GHz frequency band

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor I7 | Sensor I8 | Sensor I9 | Sensor  GSO-I1 | Sensor  GSO-I2 |
| Sensor type | Conical scan | Conical scan | Cross-track nadir scan | Wide strip and thin circle combined scan | Interferometric radiometer |
| **Orbit parameters** | | | | | |
| Altitude (km) | 407 | 830 | 595 | 35 800 | 35 800 |
| Inclination (degree) | 50 | 98.85 | 97.79 | N/A | N/A |
| Eccentricity | 0.003 | 0 | 0.001 | N/A | N/A |
| Repeat period |  |  | 9 days/30 min (single satellite/constellation) | N/A | N/A |
| **Sensor antenna parameters** | | | | | |
| Number of beams | 1 | 1 | 1 | 1 | 1 |
| Antenna size (m) | 1.1 | 1 | 0.16 | 5 | 5 |
| Maximum beam gain (dBi) | 53.0 | 52,8 | 36.3 | 66 | 66.2 |
| Polarization | V, H | V, H | QH/QV | H | H |
| −3 dB beamwidth (degree) | 0.5° |  | 2.7° | 0.09° | 0.083° |
| Instantaneous field of view (km) | 8.3 × 5.3 | 13 × 30  302.4 km2 | Nadir FOV: 28  (618 km²) Outer FOV: 54 × 118  (4 954 km²) | N/A | N/A |
| Off-nadir pointing angle (degree) | 46.1 | 53.3 | ±54.4 cross-track | N/A | N/A |
| Incidence angle at Earth (degree) | 50 | 65 | 0 (nadir) 62.8 | N/A | N/A |
| Swath width (km) | 800 | 2 200 | 1 900 | 8 scan stripes, each strip 0.9° × 7.2°, thin circle diameter 1.1° | Full disk |
| Antenna efficiency | 0.594 | 0.62 | 0.6 | 0.60 | 0.60 |
| Beam dynamics | 30 rpm | 2.5 s scan period, counter clockwise | 1.1 s (45 rpm) | General scan:  0.64°/min  Local scan:  25.75 rpm | Full disk: 10 min |
| Sensor antenna pattern | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R  [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) |
| Cold calibration antenna gain (dBi) | 50.0 | 40 | 36.3 |  |  |
| Cold calibration angle (degrees re. satellite track) | 180° | 315° | 78° to 83° |  | N/A |
| Cold calibration angle (degrees re. nadir direction) | 90° | 90° |  |  |  |
| **Sensor receiver parameters** | | | | | |
| Sensor integration time (ms) | 2.08 | 5 | 2 |  | 20 |
| Channel bandwidth (MHz) | 200 | 200 | 180 centred at 50.3 GHz | 200 | 200 |
| **Measurement spatial resolution** | | | | | |
| Horizontal resolution (km) | 9.3 | 32 |  | 50 (nadir) | 52 (nadir) |
| Vertical resolution (km) | 8.3 | 32 |  | 50 (nadir) | 52 (nadir) |

## 6.11 Typical parameters of passive sensors operating in the 52.6-54.25 GHz frequency band

This frequency band is one of the frequency bands used for close-to-nadir atmospheric sounding in conjunction with the frequency bands at 23.8 GHz, 31.5 GHz and 50.3 GHz to characterize each layer of the atmosphere.

Tables 19 and 20 summarize the parameters of passive sensors that are or will be operating in the 52.6‑54.25 GHz frequency band.

TABLE 19

EESS (passive) sensor characteristics in the 52.6-54.25 GHz frequency band

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor J1 | Sensor J3 | Sensor J4 | Sensor J5 | Sensor J6 |
| Sensor type | Mechanical nadir scan | Mechanical nadir scan | Conical scan | Mechanical nadir scan | Conical scan |
| **Orbit parameters** | | | | | |
| Altitude (km) | 833  822 \* | 824 | 835 | 830 | 830 |
| Inclination (degree) | 98.6 98.7 \* | 98.7 | 98.85 | 98.7 | 98.7 |
| Eccentricity | 0 0.001\* | 0 | 0 | 0.001 | 0.001 |
| Repeat period (days) | 9  29 \* | 9 |  | 29 | 29 |
| **Sensor antenna parameters** | | | | | |
| Number of beams | 30 earth fields per 8 s scan period | 2 | 1 | 1 | 1 |
| Antenna size (m) | 0.15 | 0.203 | 0.65 | 0.35 | 0.76 |
| Maximum beam gain (dBi) | 34.4 | 37.9 | 47.6 | 42 | 46.5 |
| Polarization | V, H QV, QH\* | QH | V | QH/QV |  |
| −3 dB beamwidth (degree) | 3.3 | 2.2 | 0.65 | 1.4 | 1 |
| Instantaneous field of view (km) | Nadir FOV:  48.5  Outer FOV:  149.1 × 79.4  147 × 79 \* | Nadir FOV: 31.6  Outer FOV: 136.7 × 60 | IFOV 18 × 44 | Nadir FOV: 20  (323 km²) Outer FOV:  67 × 35  (1 816 km²) | 22 × 36  (625 km²) |
| Off-nadir pointing angle (degree) | ±48.33 cross-track | ±52.725 cross-track | 53.3 | ±49.31 cross-track | 44.8 |
| Incidence angle at Earth (degree) | 0 57.5 \* |  | 65 | 0 (nadir) 58.9 | 52.8 |
| Swath width (km) | 2 343 2 186 \* | 2 500 | 1 600 | 2 220 | 1 700 |
| Antenna efficiency | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |

TABLE 19 (*end*)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor J1 | Sensor J3 | Sensor J4 | Sensor J5 | Sensor J6 |
| Beam dynamics | 8 s scan period | 8/3 s scan period cross‑track; 96 earth fields per scan period | 2.5 s scan period, clockwise | 2.254 s | 45 rpm (1.33 s) |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) |
| Cold calibration antenna gain (dBi) | 34.4 | 37.9 | 39 |  |  |
| Cold calibration angle (degrees re. satellite track) | 90° −90° ± 3.9°\* | 0 | 315° | 78° to 83° | 165.5° to 203° |
| Cold calibration angle (degrees re. nadir direction) | 83.33° | 82.175° | 90° |  |  |
| **Sensor receiver parameters** | | | | | |
| Sensor integration time (ms) | 165 | 18 | 5 | 13.7 | 1 to 8 |
| Channel bandwidth | 400 MHz centred at 52.8 GHz  170 MHz centred at 53.596 GHz | 400 MHz centred at 52.8 GHz  170 MHz centred at 53.596 GHz | 400 MHz centred at 52.8,  53.3 and  53.8 GHz | Table 21 | Table 22 |
| **Measurement spatial resolution** | | | | | |
| Horizontal resolution (km) | 47 48 \* | 32 | 48 |  |  |
| Vertical resolution (km) | 47  48 \* | 32 | 48 |  |  |
| NOTE – \* indicates that a particular sensor is flown on different missions, with different orbit and sensor parameters. | | | | | |

TABLE 20

EESS (passive) sensor characteristics in the 52.6-54.25 GHz frequency band

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor J7 | Sensor J8 | Sensor J9 | Sensor  GSO-J1 | Sensor  GSO-J2 |
| Sensor type | Conical scan | Conical scan | Cross-track nadir scan | Wide strip and thin circle combined scanr | Interferometric radiometer |
| **Orbit parameters** | | | | | |
| Altitude (km) | 830 | 407 | 595 | 35 800 | 35 800 |
| Inclination (degree) | 98.85 | 50 | 97.79 | N/A | N/A |
| Eccentricity | 0 | 0.003 | 0.001 | N/A | N/A |

TABLE 20 (*cont.*)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor J7 | Sensor J8 | Sensor J9 | Sensor  GSO-J1 | Sensor  GSO-J2 |
| Repeat period |  |  | 9 days/30 min (single satellite/ constellation) | N/A | N/A |
| **Sensor antenna parameters** | | | | | |
| Number of beams | 1 | 1 | 1 | 1 | 1 |
| Antenna size (m) | 1 | 1.1 | 0.16 | 5 | 5 |
| Maximum beam gain (dBi) | 52.8 | 53.5 | 36.8 | 66. | 66.7 |
| Polarization |  | H, V | QH/QV | V/H | H |
| −3 dB beamwidth (degree) | 0.45 | 0.5 | 2.7 | 0.09 | 0.08 |
| Instantaneous field of view (km) | 13 × 30  (302.4 km²) | 8.3 × 5.3 | Nadir FOV: 28  (618 km²) Outer FOV: 54 × 118  (4 954 km²) | N/A | N/A |
| Off-nadir pointing angle (degree) | 53.3 | 46.1 | 54.4 | N/A | N/A |
| Incidence angle at Earth (degree) | 65 | 50 | 0 (nadir) 62.8 | N/A | N/A |
| Swath width (km) | 2 200 | 800 | 1 900 | 8 scan stripes, each strip 0.9×7.2, thin circle diameter 1.1 | Full disk |
| Antenna efficiency | 0.61 | 0.592 | 0.6 | 0.60 | 0.60 |
| Beam dynamics | 2.5 s scan period, counter clockwise | 30 rpm | 1.1s (45 rpm) | General scan:  0.64/min  Local scan:  25.75 rpm | Full disk: 10 min |
| Sensor antenna pattern | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R  [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) |
| Cold calibration antenna gain (dBi) | 40 | 50.5 | 36.8 |  |  |
| Cold calibration angle (degrees re. satellite track) | 315 | 180 | 78° to 83° |  | N/A |
| Cold calibration angle (degrees re. nadir direction) | 90 | 90 |  |  |  |

TABLE 20 (*end*)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sensor J7 | Sensor J8 | Sensor J9 | Sensor  GSO-J1 | Sensor  GSO-J2 |
| **Sensor receiver parameters** | | | | | |
| Sensor integration time (ms) | 5 | 2.08 | 2 | 20 | 20 |
| Channel bandwidth (MHz) | 400 MHz centred at 52.8, 53.3 and  53.8 GHz | 400 MHz centred at 52.8 GHz  400 MHz centred at 53.24 GHz  400 MHz centred at 53.75 GHz | Table 23 | 400 MHz centred at 52.8 GHz  400 MHz centred at 53.596 GHz | 400 MHz centred at 52.8 GHz  400 MHz centred at 53.596 GHz |
| **Measurement spatial resolution** | | | | | |
| Horizontal resolution (km) | 32 | 9.3 |  | 50 | 50 (nadir) |
| Vertical resolution (km) | 32 | 8.3 |  | 50 (nadir) | 50 |

TABLE 21

Sensor J5 passive sensor characteristics for channels between 52.6 and 54.25 GHz

|  |  |
| --- | --- |
| Centre frequency  (GHz) | Bandwidth  (MHz) |
| 52.8 | 400 |
| 53.246 ± 0.08 | 2 × 140 |
| 53.596 ± 0.115 | 2 × 170 |
| 53.948 ± 0.081 | 2 × 142 |

TABLE 22

Sensor J6 passive sensor characteristics for channels   
between 52.6 and 54.25 GHz

|  |  |
| --- | --- |
| Centre frequency  (GHz) | Bandwidth  (MHz) |
| 52.61 | 400 |
| 53.24 | 400 |
| 53.75 | 400 |

TABLE 23

Sensor J9 passive sensor characteristics for channels between 52.6 and 54.25 GHz

|  |  |
| --- | --- |
| Centre frequency  (GHz) | Bandwidth  (MHz) |
| 52.8 | 400 |
| 53.246 | 300 |
| 53.596 | 370 |

## 6.12 Typical parameters of passive sensors operating in the 54.25-59.3 GHz frequency band

The 54.25-59.3 GHz frequency band is of primary interest for atmospheric temperature profiling (O2absorption lines). Tables 24 and 25 summarize the parameters of passive sensors that are or will be operating between 54.25 and 59.3 GHz. The frequency range from 54.25 to 60.3 GHz is covered by many smaller frequency bands with varying bandwidths and polarizations (see Tables 26 through 32).

TABLE 24

EESS (passive) sensor characteristics operating in the 54.25-59.3 GHz frequency band

|  | Sensor K2 | Sensor K3 | Sensor K4 | Sensor K5 |
| --- | --- | --- | --- | --- |
| Sensor type | Mechanical nadir scan | Mechanical nadir scan | Conical scan | Conical scan |
| **Orbit parameters** | | | | |
| Altitude (km) | 824 | 833 822 \* | 835 | 830 |
| Inclination (degree) | 98.7 | 98.6 98.7 \* | 98.85 | 98.85 |
| Eccentricity | 0 | 0 0.001\* | 0 | 0 |
| Repeat period (days) | 9 | 9 29 \* |  |  |
| **Sensor antenna parameters** | | | | |
| Number of beams | 2 | 30 earth fields per 8 s scan period | See Table 28 | See Table 28 |
| Antenna size (m) | 0.203 | 0.15 | 0.65 | 1 |
| Maximum beam gain (dBi) | 37.9 | 34.4 | 47.6 | 53.4 |
| Polarization | See Table 26 | See Table 27 | See Table 28 | See Table 28 |
| −3 dB beamwidth | 2.2° | 3.3 | 0.65° | 0.42° |
| Instantaneous field of view | Nadir FOV: 31.6 km Outer FOV: 136.7 × 60 km | Nadir FOV: 48.5 km (3.3) Outer FOV: 149.1 × 79.4 km 147 × 79 km\* | Outer FOV 18 × 43 km | 12 × 28 km  264 km² |
| Off-nadir pointing angle (degree) | ±52.725 cross-track | ±48.33 cross-track | 53.3 | 53.3 |
| Incidence angle at Earth |  | 57.5°\* | 65 | 65 |
| Swath width (km) | 2 500 | 2 343 | 1 600 | 1 600 |

TABLE 24 (*end*)

EESS (passive) sensor characteristics operating in the 54.25-59.3 GHz frequency band

|  | Sensor K2 | Sensor K3 | Sensor K4 | Sensor K5 |
| --- | --- | --- | --- | --- |
| Antenna efficiency | 0.60 | 0.60 | 1.00 | 0.62 |
| Beam dynamics | 8/3 s scan period cross-track; 96 earth fields per scan period | 8 s scan period | 2.5 s scan period, clockwise | 2.5 s scan period, clockwise |
| Sensor antenna pattern | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain (dBi) | 37.9 | 34.4 | 39 | 40 |
| Cold calibration angle (degrees re. satellite track) | 0 | 90−90° ± 3.9° \* | 315 | 315 |
| Cold calibration angle (degrees re. nadir direction) | 82.175 | 83.33 | 90 | 90 |
| **Sensor receiver parameters** | | | | |
| Sensor integration time (ms) | 18 | 165 | 5 | 5 |
| Channel bandwidth | See Table 26 | See Table 27 | See Table 28 | See Table 28 |
| **Measurement spatial resolution** | | | | |
| Horizontal resolution (km) | 32 | 48 | See Table 29 | See Table 29 |
| Vertical resolution (km) | 32 | 48 | See Table 29 | See Table 29 |

TABLE 25

EESS (passive) sensor characteristics operating in the 54.25-59.3 GHz frequency band

|  | Sensor K6 | Sensor K7 | Sensor GSO-K1 | Sensor  GSO-K2 |
| --- | --- | --- | --- | --- |
| Sensor type | Cross-track scan | Conical scan | Wide strip and thin circle combined scan | Interferometric radiometer |
| **Orbit parameters** | | | | |
| Altitude (km) | 595 | 830 | 35 800 | 35 800 |
| Inclination (degree) | 97.79 | 98.7 | N/A | N/A |
| Eccentricity | 0.001 | 0.001 | N/A | N/A |
| Repeat period | 9 days/30 min (single satellite/ constellation) | 29 days | N/A | N/A |
| **Sensor antenna parameters** | | | | |
| Number of beams | 1 | 1 | 1 | 1 |
| Antenna size (m) | 0.16 | 0.35 | 5 | 5 |
| Maximum beam gain (dBi) | 37.4 | 44 | 66 | 67.3 |
| Polarization | QH/QV | QH/QV | See Table 32 | See Table 32 |
| −3 dB beamwidth (degree) | 2.7 | 1.4 | 0.09 | 0.074 |

TABLE 25 (*end*)

|  | Sensor K6 | Sensor K7 | Sensor GSO-K1 | Sensor  GSO-K2 |
| --- | --- | --- | --- | --- |
| Instantaneous field of view | Nadir FOV: 28 km  (618 km²) Outer FOV: 54 × 118 km  (4 954 km²) | Nadir FOV: 20 km  (323 km²) Outer FOV: 67 × 35 km  (1 816 km²) | N/A | N/A |
| Off-nadir pointing angle (degree) | 54.4 | ±49.31 cross-track |  | N/A |
| Incidence angle at Earth (degree) | 0 (nadir) 62.8 | 0 (nadir) 58.9 | N/A | N/A |
| Swath width | 1 900 km | 2 220 km | 8 scan stripes, each strip 0.9×7.2, thin circle diameter 1.1 | Full disk |
| Antenna efficiency | 0.6 | 0.6 | 0.60 | 0.60 |
| Beam dynamics | 1.1 s (45 rpm) | 2.254 s | General scan:  0.64/min  Local scan:  25.75 rpm | Full disk: 10 min |
| Sensor antenna pattern | Rec. ITU‑R  RS.1813 | Rec. ITU‑R RS.1813 |  |  |
| Cold calibration ant. gain (dBi) | 37.4 |  |  |  |
| Cold calibration angle (degrees re. satellite track) | 78° to 83° | 78° to 83° |  | N/A |
| Cold calibration angle (degrees re. nadir direction) |  |  |  |  |
| **Sensor receiver parameters** | | | | |
| Sensor integration time (ms) | 2 | 13.7 |  | 20 |
| Channel bandwidth | See Table 30 | See Table 31 | See Table 32 | See Table 32 |
| **Measurement spatial resolution** | | | | |
| Horizontal resolution (km) |  |  | 50 | 47 (nadir) |
| Vertical resolution (km) |  |  | 50 | 47 (nadir) |

TABLE 26

Sensor K2 passive sensor characteristics for channels between 54.25 and 59.3 GHz

| Centre frequency  (GHz) | Channel bandwidth  (MHz) | Polarization |
| --- | --- | --- |
| 54.4 | 400 | QH |
| 54.94 | 400 | QH |
| 55.5 | 330 | QH |
| 57.290344 | 330 | QH |
| 57.073344, 57.507344 | 78 | QH |
| 57.660544, 57.564544, 57.016144, 56.920144 | 36 | QH |
| 57.634544, 57.590544, 56.990144, 56.946144 | 16 | QH |
| 57.622544, 57.602544, 56.978144, 56.958144 | 8 | QH |
| 57.617044, 57.608044, 56.972644, 56.963644 | 3 | QH |

TABLE 27

Sensor K3 passive sensor characteristics for channels between 54.25 and 59.3 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency (GHz) | Channel bandwidth  (MHz) | Polarization |
| 54.4 | 400 | H, QH\* |
| 54.94 | 400 | V, QV\* |
| 55.5 | 330 | H, QH\* |
| 57.290344 | 330 | H, QH\* |
| 57.073344, 57.507344 | 78 | H, QH\* |
| 57.660544, 57.564544, 57.016144, 56.920144 | 36 | H, QH\* |
| 57.634544, 57.590544, 56.990144, 56.946144 | 16 | H, QH\* |
| 57.622544, 57.602544, 56.978144, 56.958144 | 8 | H, QH\* |
| 57.617044, 57.608044, 56.972644, 56.963644 | 3 | H, QH\* |
| NOTE – \* indicates that a particular sensor is flown on different missions, with different parameters. | | |

TABLE 28

Sensors K4 and K5 passive sensor characteristics for channels between 54.25 and 60.5 GHz

| Centre frequency  (GHz) | Number of beams | Channel bandwidth  (MHz) | Polarization | Altitude of peak sensitivity (km) |
| --- | --- | --- | --- | --- |
| 54.64 | 1 | 400 | V | 10 |
| 55.63 | 1 | 400 | V | 14 |
| 57.290344 ± 0.322 ± 0.1 | 4 | 50 | H | 20 |
| 57.290344 ± 0.322 ± 0.05 | 4 | 20 | H | 25 |
| 57.290344 ± 0.322 ± 0.025 | 4 | 10 | H | 29 |
| 57.290344 ± 0.322 ± 0.01 | 4 | 5 | H | 35 |
| 57.290344 ± 0.322 ± 0.005 | 4 | 3 | H | 42 |

TABLE 29

Sensors K4 and K5 passive sensor measurement spatial resolutions  
for channels between 54.25 and 60.5 GHz

|  | Sensor K4 | | Sensor K5 | |
| --- | --- | --- | --- | --- |
| Centre frequency  (GHz) | Measurement spatial resolution (horizontal) (km) | Measurement spatial resolution (vertical) (km) | Measurement spatial resolution (horizontal) (km) | Measurement spatial resolution (vertical) (km) |
| 54.64 | 48 | 48 | 32 | 32 |
| 55.63 | 48 | 48 | 32 | 32 |
| 57.290344 ± 0.322 ± 0.1 | 48 | 48 | 48 | 48 |
| 57.290344 ± 0.322 ± 0.05 | 48 | 48 | 48 | 48 |
| 57.290344 ± 0.322 ± 0.025 | 48 | 48 | 96 | 96 |
| 57.290344 ± 0.322 ± 0.01 | 48 | 48 | 96 | 96 |
| 57.290344 ± 0.322 ± 0.005 | 48 | 48 | 96 | 96 |

TABLE 30

Sensor K6 passive sensor characteristics for channels between 54.25 and 59.3 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) | Polarization |
| 54.40 | 400 | H |
| 54.94 | 400 | H |
| 55.50 | 330 | H |
| 57.290344 | 330 | H |

TABLE 31

Sensor K7 passive sensor characteristics for channels between 54.25 and 59.3 GHz

|  |  |
| --- | --- |
| Centre frequency  (GHz) | Bandwidth (MHz) |
| 54.4 | 400 |
| 54.94 | 400 |
| 55.5 | 330 |
| 57.290344 | 330 |
| 57.290344 ± 0.217 | 2 × 78 |
| 57.290344 ± 0.3222 ± 0.048 | 4 × 36 |
| 57.290344 ± 0.3222 ± 0.022 | 4 × 16 |
| 57.290344 ± 0.3222 ± 0.010 | 4 × 8 |
| 57.290344 ± 0.3222 ± 0.0045 | 4 × 3 |

TABLE 32

Sensors GSO-K1 and GSO-K2 passive sensor characteristics   
for channels between 54.25 and 59.3 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency  (GHz) | Channel bandwidth (MHz) | Polarization |
| 57.290344 ± 0.217 | 80 | H |
| 57.290344 ± 0.322 ± 0.048 | 40 | H |
| 57.290344 ± 0.322 ± 0.022 | 20 | H |
| 57.290344 ± 0.322 ± 0.010 | 10 | H |
| 57.290344 ± 0.322 ± 0.0045 | 5 | H |

## 6.13 Typical parameters of passive sensors operating in the 86-92 GHz frequency band

The 86-92 GHz frequency band is essential for the measurement of clouds, oil spills, ice, snow, and rain. It is also used as a reference window for temperature soundings near 118 GHz. Tables 33 and 34 summarize the parameters of passive sensors that are or will be operating within the 86 and 92 GHz frequency band.

TABLE 33

EESS (passive) sensor characteristics operating in the 86-92 GHz frequency band

|  | Sensor L1 | Sensor L4 | Sensor L5 | Sensor L6 | Sensor L7 | Sensor L8 | Sensor L9 | Sensor L10 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Conical scan | Mechanical nadir scan | Mechanical nadir scan | Mechanical nadir scan | Conical scan | Conical scan | Mechanical nadir scan | Conical scan |
| **Orbit parameters** | | | | | | | | |
| Altitude (km) | 867 | 833 822 \* | 833 822 \* | 824 | 835 | 700 | 83 | 830 |
| Inclination (degree) | 20 | 98.6 98.7 \* | 98.6 98.7 \* | 98.7 | 98.85 | 98.2 | 98.7 | 98.7 |
| Eccentricity | 0 | 0 0.001\* | 0 0.001\* | 0 | 0 | 0.002 | 0.001 | 0.001 |
| Repeat period (days) | 7 | 9 29 \* | 9 29 \* | 9 |  | 16 | 29 | 29 |
| **Sensor antenna parameters** | | | | | | | | |
| Number of beams | 1 | 30 earth fields per 8 s scan period | 30 earth fields per 8 s scan period  1 beam (steerable in 90 earth fields per scan period)\* | 2 | 2 | 2 | 1 | 1 |
| Antenna size (m) | 0.65 | 0.15 | 0.3 0.22 \* | 0.203 | 0.65 | 2 | 0.35 | 0.76 |
| Maximum beam gain (dBi) | 50 | 34.4 | 47 44.8 \* | 37.9 | 52.5 | 62.4 | 43 | 55.1 |
| Polarization | H, V | H QV \* | H QV \* | QV | H, V | H, V | QH/QV | V, H |
| −3 dB beamwidth (degree) | 0.43 | 3.3 | 1.1 | 2.2 | 0.6 | 0.15 | 1.15 | 1 |

TABLE 33 (*cont.*)

|  | Sensor L1 | Sensor L4 | Sensor L5 | Sensor L6 | Sensor L7 | Sensor L8 | Sensor L9 | Sensor L10 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Instantaneous field of view (km) | 10 km × 17 km | Nadir FOV: 48.5 km  Outer FOV: 149.1 × 79.4 km 147 × 79 km\* | Nadir FOV: 16 km (1.1°) Outer FOV: 53 × 27 km\* | Nadir FOV: 31.6 km × 31.6 km  Outer FOV: 136.7 × 60 km | 17 km × 40 km | A: 5.1 km × 2.9 km B: 5.0 km × 2.9 km | Nadir FOV: 17 km  (218 km²) Outer FOV: 55 × 28 km  (1 225 km²) | 22 × 36 km  (625 km²) |
| Off-nadir pointing angle (degree) | 44.5 | ±48.33 cross-track | ±48.95 49.4\* | ±52.725 cross-track | 53.3 | 47.5° | ±49.31 cross-track | 44.8 |
| Incidence angle at Earth (degree) | 53.5° | 30 positions 57.5°\* | Various angles from 0°  59°\* |  | 65° | 55° | 0° (nadir) 58.9° | 52.8° |
| Swath width (km) | 1 700 | 2 343  2 186 \* | 2 343  2 193 \* | 2 500 | 1600 | 1 450 | 2 220 | 1 700 |
| Antenna efficiency | 0.27 | 0.14 | 0.64 | 0.17 | 0.81 | 0.52 | 0.6 | 0.6 |
| Beam dynamics | 20 rpm | 8 s scan period | 8/3 s scan period | 8/3 s scan period cross-track;  96 earth fields per scan period | 2.5 s scan period, clockwise | 40 rpm | 2.254 s | 45 rpm (1.33 s) |
| Sensor antenna pattern |  |  |  |  |  |  | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain (dBi) | N/A | 34.4 | 34.4 44.8 \* | 37.9 | 44 | 43.4 |  |  |
| Cold calibration angle (degrees re. satellite track) | N/A | 90° −90° ± 3.9°\* | End of scan (at 48.95°) −90° ± 3.9°\* | 0 | 315° | 115.5º | 78° to 83° | 165.5° to 203° |
| Cold calibration angle (degrees re. nadir direction) | N/A | 83.33° | 83.33°  73.6 (66° to 81°)\* | 82.175° | 90° | 97.0º |  |  |

TABLE 33 (*end*)

|  | Sensor L1 | Sensor L4 | Sensor L5 | Sensor L6 | Sensor L7 | Sensor L8 | Sensor L9 | Sensor L10 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sensor receiver parameters** | | | | | | | | |
| Sensor integration time (ms) | 2 | 180 165 \* | 185 18 \* | 18 | 5 | 1.2 | 13.7 | 1 to 8 |
| Channel bandwidth (MHz) | 2 700 MHz centred at 89 GHz | 6 000 MHz centred at 89 GHz | Centred at 89 GHz  ±500 MHz, each with a bandwidth of 1 000 MHz  2 800 MHz centred at 89 GHz\* | 2 000 MHz centred at 87‑91.9 GHz | 2.5 GHz centred at 91.655 GHz | 3 000 MHz centred at 89 GHz | 4 000 MHz  Centred at 89 GHz | 4 000 MHz Centred at 89 GHz |
| **Measurement spatial resolution** | | | | | | | | |
| Horizontal resolution (km) | 10 | 40.5 48 \* | 40.5 16 \* | 32 | 16 | 2.9 |  |  |
| Vertical resolution (km) | N/A | 48 | 16 | 32 | 16 | 5.1 |  |  |
| NOTE – \* indicates that a particular sensor is flown on different missions, with different orbit and sensor parameters. | | | | | | | | |

TABLE 34

EESS (passive) sensor characteristics operating in the 86-92 GHz frequency band

|  | Sensor L11 | Sensor L12 | Sensor L13 | Sensor L14 | Sensor L15 | Sensor L16 | Sensor L17 | Sensor  GSO-L1 | Sensor  GSO-L2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Conical scan | Conical scan | Cross-track nadir scan | Conical scan | Mechanical nadir scan | Nadir | Conical scan | Wide strip and thin circle combined scanning radiometer | Interferometric radiometer |
| **Orbit parameters** | | | | | | | | | |
| Altitude (km) | 830 | 407 | 595 | 407 | 550 | 1 336 | 665.96 | 35800 | 35800 |
| Inclination (degree) | 98.85 | 50 | 97.79 | 65 | 30 | 66 | 98.06 | N/A | N/A |

TABLE 34 (*cont.*)

|  | Sensor L11 | Sensor L12 | Sensor L13 | Sensor L14 | Sensor L15 | Sensor L16 | Sensor L17 | Sensor  GSO-L1 | Sensor  GSO-L2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Eccentricity | 0 | 0.003 | 0.001 | 0 | 0 | 0 | 0.0015 | N/A | N/A |
| Repeat period |  |  | 9 days/30 min (single satellite/constellation) | 43.5 days | 18.6 days | 9.92 days | 3 days | N/A | N/A |
| **Sensor antenna parameters** | | | | | | | | | |
| Number of beams | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| Antenna size (m) | 1 | 1.1 | 0.16 | 1.22 | 0.083 | 1 | 2 | 5 | 5 |
| Maximum beam gain (dBi) | 57.4 | 58 | 41.3 | 53.8 | 35.0 | 57.0 | 62.4 | 69.5 | 71.1 |
| Polarization | V, H | H, V | QH/QV | H/V | H/V | Single Linear | H, V | V | V |
| −3 dB beamwidth (degree) | 0.27 | 0.4 | 1.75 | 0.38 | 2.89 | 0.31 | 0.15 | 0.07 | 0.05 |
| Instantaneous field of view (km) | 8 × 18  (105 km²) | 7.5 × 4.5 | Nadir FOV: 18  (259 km²) Outer FOV: 35 × 76  (2 076 km²) | 7.2 × 4.4 | Nadir IFOV: 27.7  Outer IFOV: 195.6 × 65.6 | 7 × 7 | A: 5 × 3 B: 5 × 3 | 39 × 39 | N/A |
| Off-nadir pointing angle (degree) | 53.3 | 48.6 | 54.4 | 48.5 | ±60 cross-track | 3.4 along-track | 47.7 | N/A | N/A |
| Incidence angle at Earth (degree) | 65 | 53 | 0 (nadir) 62.8 | 52.8 | ≤ 70.2 | 4.1 | 55 | N/A | N/A |
| Swath width (km) | 2 200 | 800 | 1 900 | 921 | 2480 | 7 | 1535 | 8 scan stripes, each strip 0.9×7.2, thin circle diameter 1.1 | Full disk |
| Antenna efficiency | 0.63 | 0.60 |  |  | 0.53 | 0.56 | 0.50 | 0.60 | 0.60 |
| Beam dynamics | 2.5 s scan period, counter clockwise | 30 rpm | 1.1 s (45 rpm) | 32 rpm | 2 s scan period | N/A | 40 rpm | General scan:  0.64/min  Local scan:  25.75 rpm | Full disk: 10 min |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain (dBi) | 45 | 55 | 41.3 | 37.7 | 35.0 | N/A | 43.4 |  |  |

TABLE 34 (*end*)

|  | Sensor L11 | Sensor L12 | Sensor L13 | Sensor L14 | Sensor L15 | Sensor L16 | Sensor L17 | Sensor  GSO-L1 | Sensor  GSO-L2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Cold calibration angle (degrees re. satellite track) | 315° | 180° | 78° to 83° | 206.7° (CCW) | 0° | N/A | 118.7º |  | N/A |
| Cold calibration angle (degrees re. nadir direction) | 90° | 90° |  | 107.5° | 120° | N/A | 94.6º |  |  |
| **Sensor receiver parameters** | | | | | | | | | |
| Sensor integration time (ms) | 5 | 2.08 | 2 | 3.6 | 8.3 | 125 | 1.2 |  | 20 |
| Channel bandwidth | 2.5 GHz centred at 91.655 GHz | 3000 MHz centred at 89 GHz | 4 000 MHz centred at 89 GHz | 6 000 MHz centred at 89 GHz | 1 000 MHz centred at 90.256 GHz | 5 GHz centred at 90 GHz | 3 000 MHz centred at 89 GHz | 2000 MHz centred at 88.2 GHz | 2000 MHz centred at 88.2 GHz |
| **Measurement spatial resolution** | | | | | | | | | |
| Horizontal resolution (km) | 16 | 8.7 |  | 4.4 | 27.7 | 7 | 3 | 39 (nadir) | 30 (nadir) |
| Vertical resolution (km) | 16 | 7.5 |  | 7.2 | 27.7 | 7 | 5 | 39 (nadir) | 30 (nadir) |

## 6.14 Typical parameters of passive sensors operating in the 114.25-122.25 GHz frequency band

The frequency range 114.25-122.25 GHz is of primary interest for atmospheric temperature profiling (O2absorption lines). Table 35 summarizes the parameters of passive sensors that are or will be operating in the frequency range of 114.25 and 122.25 GHz.

TABLE 35

EESS (passive) sensor characteristics operating in the 114.25 - 122.25 GHz frequency band

|  | Sensor M1 | Sensor M2 | Sensor M3 | Sensor M4 | Sensor M5 | Sensor M6 | Sensor GSO-M1 | Sensor GSO-M2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Limb sounder | Conical scan | Conical scan | Nadir scan | Mechanical nadir scan | Conical scan | Raster scan | Wide strip and thin circle combined scan |
| **Orbit parameters** | | | | | | | | |
| Altitude (km) | 705 | 407 | 836 | 836 | 550 | 830 | 35 800 | 35 800 |
| Inclination (degree) | 98.2 | 50 | 98.75 | 98.75 | 30 | 98.7 | N/A | N/A |
| Eccentricity | 0 | 0.003 | 0.003 | 0.003 | 0 | 0.001 | N/A | N/A |
| Repeat period (days) | 16 |  | 5.5 | 5.5 | 18.6 | 29 | N/A | N/A |
| **Sensor antenna parameters** | | | | | | | | |
| Number of beams | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Antenna size (m) | 1.6 (V) × 0.8 (H) | 1.1 | 1.1 | 0.22 | 0.083 | 0.76 | 3 | 5 |
| Maximum beam gain (dBi) | 62 | 60.5 | 60.5 | 46.5 | 37.8 | 55.5 | 69.2 | 70.5 |
| Polarization | H, V | V | V | H | H/V | V | H | H |
| −3 dB beamwidth (degree) | 0.119 × 0.245 | 0.35 | 0.35 | 1.8 | 2.41 | 0.33 | 0.06 | 0.055 |
| Instantaneous field of view (km) | 6.5 × 13 | 5.8 × 3.7 | 11.5 × 7.4 | Nadir: 26 | Nadir IFOV: 23.1  Outer IFOV: 162.6 × 54.7 | 7 × 12  (68 km²) | Nadir: 37 | Nadir:  34 |
| Off-nadir pointing angle | Limb | 46.1° | 42.6° | ±53.35° cross-track | ±60° cross-track | 44.8° | N/A | N/A |
| Incidence angle at Earth (degree) | N/A | 50 | 50 | 0 (nadir) | ≤ 70.2 | 52.8 | N/A | N/A |
| Swath width (km) | N/A | 800 | 1 400 | 2 000 | 2 480 | 1 700 | Full disk | 8 scan stripes, each strip 0.9×7.2, thin circle diameter 1.1 |
| Antenna efficiency | 0.80 | 0.604 | 0.604 | 0.604 | 0.56 | 0.6 | 0.60 | 0.60 | |

TABLE 35 (*end*)

|  | Sensor M1 | Sensor M2 | Sensor M3 | Sensor M4 | Sensor M5 | Sensor M6 | Sensor GSO-M1 | Sensor GSO-M2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Beam dynamics | Scans continuously in tangent height from the surface to ~92 km in 24.7 s, 240 scans/orbit | 30 rpm | 30 rpm | 8/3 s scan period  1.71 s for 96 earth fields per scan period | 2 s scan period | 45 rpm (1.33 s) | Full disk: 45 min | General scan:  0.64°/min  Local scan:  25.75 rpm |
| Sensor antenna pattern | See Rec. ITU-R RS.1813 with minor mods (see NOTE below) | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain (dBi) | N/A | 57.5 | 57.5 | 46.5 | 37.8 |  |  |  |
| Cold calibration angle (degrees re. satellite track) | N/A | 180° | 180° | 90° | 0° | 165.5° to 203° | N/A |  |
| Cold calibration angle (degrees re. nadir direction) | N/A | 90° | 90° | 74° | 120° |  |  |  |
| **Sensor receiver parameters** | | | | | | | | |
| Sensor integration time | 0.166 s | 2.08 ms | 2.08 ms | 17 ms | 8.3 ms | 1 to 8 ms | 10 ms |  |
| Channel bandwidth | See Table 36 | See Table 37 | See Table 37 | See Table 38 | See Table 39 | See Table 40 | See Table 38 | See Table 41 |
| **Measurement spatial resolution** | | | | | | | | |
| Horizontal resolution (km) | 13 | 7.7 | 15.3 | 42 (nadir) | 23.1 |  | 49 (nadir) |  |
| Vertical resolution (km) | 6.5 | 5.8 | 11.5 | 26 (nadir) | 23.1 |  | 37 (nadir) |  |

NOTE – The antenna model from Recommendation ITU-R RS.1813-1 can be adjusted to support elliptical reflectors with the following modifications:

• The maximum antenna gain be defined as: .

• The antenna diameter be defined as: . Therefore, the antenna diameter becomes a function of the angle (α ϵ [0°, 90°]) in the plane that is perpendicular to the antenna boresight vector and between the intended direction of emission and the antenna beam’s major axis.

• The existing functions for G(φ) and φm should be evaluated for each point in the alpha/phi space.

TABLE 36

Sensor M1 passive sensor characteristics for channels between 114.25 and 122.25 GHz

|  |  |
| --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) |
| 115.3 | 500 |
| 117 | 500 |
| 118.753 | 10 |
| 118.753 | 1250 |
| 120.5 | 500 |
| 122 | 500 |

TABLE 37

Sensor M2 and M3 passive sensor characteristics   
for channels between 114.25 and 122.25 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) | Polarization |
| 118.7503 ± 3.2 | 1 000 | V |
| 118.7503 ± 2.1 | 800 | V |
| 118.7503 ± 1.4 | 800 | V |
| 118.7503 ± 1.2 | 800 | V |

TABLE 38

Sensor M4 and GSO-M1 passive sensor characteristics for channels between   
114.25 and 122.25 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) | Polarization |
| 118.7503 ± 0.08 | 40 | H |
| 118.7503 ± 0.2 | 200 | H |
| 118.7503 ± 0.3 | 330 | H |
| 118.7503 ± 0.8 | 400 | H |
| 118.7503 ± 1.1 | 400 | H |
| 118.7503 ± 2.5 | 400 | H |
| 118.7503 ± 3.0 | 2 000 | H |

TABLE 39

Sensor M5 passive sensor characteristics for channels between 114.25 and 122.25 GHz

|  |  |
| --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) |
| 114.5 | 1000 |
| 115.95 | 800 |
| 116.65 | 600 |
| 117.25 | 600 |
| 117.8 | 500 |
| 118.24 | 380 |
| 118.58 | 300 |

TABLE 40

Sensor M6 passive sensor characteristics for channels between 114.25 and 122.25 GHz

|  |  |
| --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) |
| 118.75 ± 3.2 | 2 × 500 |
| 118.75 ± 2.1 | 2 × 400 |
| 118.75 ± 1.4 | 2 × 400 |
| 118.75 ± 1.2 | 2 × 400 |

TABLE 41

Sensor GSO-M2 passive sensor characteristics for channels between 114.25 and 122.25 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) | Polarization |
| 118.7503 ± 0.08 | 40 | H |
| 118.7503 ± 0.2 | 200 | H |
| 118.7503 ± 0.3 | 330 | H |
| 118.7503 ± 0.8 | 400 | H |
| 118.7503 ± 1.1 | 400 | H |
| 118.7503 ± 2.5 | 400 | H |
| 118.7503 ± 3.0 | 2 000 | H |
| 118.7503 ± 5.0 | 2 000 | H |

## 6.15 Typical parameters of passive sensors operating in the 148.5-151.5 GHz frequency band

The 148.5-151.5 GHz frequency band is essential for passive sensor measurement of N2O, Earth’s surface temperature, and cloud parameters. It is also used as a reference window for temperature soundings. Table 42 summarizes the parameters of passive sensors that are or will be operating in the148.5 and 151.5 GHz frequency band.

TABLE 42

EESS (passive) sensor characteristics operating in the 148.5 and 151.5 GHz frequency band

|  | Sensor N1 |
| --- | --- |
| Sensor type | Cross-track nadir scan |
| **Orbit parameters** | |
| Altitude (km) | 705 |
| Inclination (degree) | 98.2 |
| Eccentricity | 0.0015 |
| Repeat period (days) | 16 |
| **Sensor antenna parameters** | |
| Number of beams | 1 |
| Antenna size (m) | 0.219 |
| Maximum beam gain (dB) | 45 |
| Polarization | Linear |
| −3 dB beamwidth (degree) | 1.1 |
| Instantaneous field of view |  |
| Off-nadir pointing angle (degree) | ±48.95 |
| Incidence angle at Earth (degree) | 56.9 |
| Swath width (km) | 1 650 |
| Antenna efficiency | 0.27 |
| Beam dynamics | Scan period of 8/3 s |
| Sensor antenna pattern | See Fig. 13 |
| Cold calibration ant. gain (dB) | 45 |
| Cold calibration angle (degrees re. satellite track) | 90° |
| Cold calibration angle (degrees re. nadir direction) | 65-81 |
| **Sensor receiver parameters** | |
| Sensor integration time (ms) | 18 |
| Channel bandwidth | 4 000 MHz @ 150 GHz |
| **Measurement spatial resolution** | |
| Horizontal resolution (km) | 13.5 |
| Vertical resolution (km) | 13.5 |

FIGURE 13

Sensor N1 antenna pattern for the 148.5-151.5 GHz frequency band

**Chart, bar chart, histogram

Description automatically generated**

## 6.16 Typical parameters of passive sensors operating in the 155.5‑158.5 GHz frequency band

The frequency band 155.5-158.5 GHz is of primary interest to measure Earth and cloud parameters. Table 43 summarizes the parameters of passive sensors that are or will be operating in the frequency band 155.5‑158.5 GHz.

WRC-2000 decided to remove the EESS (passive) allocation in the frequency band 155.5-158.5 GHz per RR No. **5.562F***, In the band 155.5-158.5 GHz, the allocation to the Earth exploration-satellite (passive) and space research (passive) services shall terminate on 1 January 2018. (WRC-2000).*

There are currently six EESS (passive) satellites with sensors operating in this frequency band. It is important to retain the sensor parameters in this Recommendation until these satellites are no longer operational. This frequency band is not planned for passive sensing for future systems.

TABLE 43

EESS (passive) sensor characteristics operating in the 155.5‑158.5 GHz frequency band

|  | Sensor O1 | Sensor O2 |
| --- | --- | --- |
| Sensor type | Conical scan | Cross-track nadir scan |
| **Orbit parameters** | | |
| Altitude (km) | 865 | 822 |
| Inclination (degree) | 20 | 98.7 |
| Eccentricity | 0 | 0.001 |
| Repeat period (days) | 7 | 29 |
| **Sensor antenna parameters** | | |
| Number of beams |  | 1 |
| Antenna size (m) | 0.65 | 0.22 |
| Maximum beam gain (dBi) | 60 | 44.8 |
| Polarization | H, V | QV |
| −3 dB beamwidth (degree) |  | 1.1 |
| Instantaneous field of view |  | Nadir FOV: 16 km Outer FOV: 53 × 27 km |
| Off-nadir pointing angle (degree) | 44.5 | 49.45 |
| Incidence angle at Earth (degree) | 52.3 | 59 |
| Swath width (km) |  | 2 193 |
| Antenna efficiency | 0.88 | 0.23 |
| Beam dynamics | 20 rpm | Scan period of 8/3s |
| Sensor antenna pattern |  |  |
| Cold calibration ant. gain (dBi) | N/A | 44.8 |
| Cold calibration angle (degrees re. satellite track) | N/A | −90° ± 3.9° |
| Cold calibration angle (degrees re. nadir direction) | N/A | 73.6  (66° to 81°) |
| **Sensor receiver parameters** | | |
| Sensor integration time (ms) | N/A | 18 |
| Channel bandwidth (GHz) | 2 | < 2.8 |
| **Measurement spatial resolution** | | |
| Horizontal resolution (km) | 6 | 16 |
| Vertical resolution (km) | 6 | 16 |

## 6.17 Typical parameters of passive sensors operating in the 164-167 GHz frequency band

The 164-167 GHz frequency band is of primary interest to measure N2O, cloud water and ice, rain, CO, and ClO. Tables 44 and 45 summarize the parameters of passive sensors that are or will be operating in the 164-167 GHz frequency band.

TABLE 44

EESS (passive) sensor characteristics operating in the 164-167 GHz frequency band

|  | Sensor P2 | Sensor P3 | Sensor P4 | Sensor P5 | Sensor P6 |
| --- | --- | --- | --- | --- | --- |
| Sensor type | Mechanical nadir scan | Conical scan | Conical scan | Conical scan | Nadir scan |
| **Orbit parameters** | | | | | |
| Altitude (km) | 824 | 830 | 407 | 836 | 836 |
| Inclination (degree) | 98.7 | 98.85 | 50 | 98.75 | 98.75 |
| Eccentricity | 0 | 0 | 0.003 | 0.003 | 0.003 |
| Repeat period (days) | 9 |  |  | 5.5 | 5.5 |
| **Sensor antenna parameters** | | | | | |
| Number of beams | 2 | 1 | 1 | 1 | 1 |
| Antenna size (m) | 0.127 | 1 | 0.8 | 0.8 | 0.22 |
| Maximum beam gain (dBi) | 43.9 | 62.6 | 60.6 | 60.6 | 49.4 |
| Polarization | QH | V | V | V | V |
| −3 dB beamwidth (degree) | 1.1 | 0.15 | 0.35 | 0.35 | 1.2 |
| Instantaneous field of view | Nadir FOV: 15.8 km Outer FOV: 68.4 × 30 km | 4 km × 9 km | 6.5 km × 3.9 km | 12.9 km × 7.8 km | Nadir: 18 km |
| Off-nadir pointing angle (degree) | ±52.725 cross-track | 53.3 | 48.6 | 44.9 | ±53.35 cross-track |
| Incidence angle at Earth (degree) | 0 | 65° | 53° | 53° | 0° (nadir) |
| Swath width (km) | 2 500 | 2 200 | 800 | 1 400 | 2 000 |
| Antenna efficiency | 0.51 | 0.61 | 0.597 | 0.597 | 0.61 |
| Beam dynamics | 8/3 s scan period cross-track;  96 earth fields per scan period | 2.5 s scan period, counter clockwise | 30 rpm | 30 rpm | 8/3 s scan period  1.71 s for 96 earth fields per scan period |
| Sensor antenna pattern |  | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) | Rec. ITU‑R [RS.1813](http://www.itu.int/rec/R-REC-RS.1813/en) |
| Cold calibration ant. gain (dBi) | 43.9 | 49.4 | 57.6 | 57.6 | 49.4 |
| Cold calibration angle (degrees re. satellite track) | 0° | 315° | 180° | 180° | 90° |
| Cold calibration angle (degrees re. nadir direction) | 82.175° | 90° | 90° | 90° | 74° |

TABLE 44 (*end*)

|  | Sensor P2 | Sensor P3 | Sensor P4 | Sensor P5 | Sensor P6 |
| --- | --- | --- | --- | --- | --- |
| **Sensor receiver parameters** | | | | | |
| Sensor integration time (ms) | 18 | 5 | 2.08 | 2.08 | 17 |
| Channel bandwidth | 3 000 MHz centred at 164-167 GHz | 3 000 MHz centred at 165.5 GHz | 1 350 MHz centred at 165.5 ± 0.75 GHz | 1 350 MHz centred at 165.5 ± 0.75 GHz | 1 500 MHz centred at 166 GHz |
| **Measurement spatial resolution** | | | | | |
| Horizontal resolution (km) | 32 | 32 | 8.1 | 16.1 | 34 (nadir) |
| Vertical resolution (km) | 32 | 32 | 6.5 | 12.9 | 18 (nadir) |

TABLE 45

EESS (passive) sensor characteristics operating in the 164-167 GHz frequency band

|  | Sensor P7 | Sensor P8 | Sensor P9 | Sensor P10 | Sensor P11 | Sensor P12 | Sensor GSO-P1 | Sensor GSO-P2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sensor type | Cross-track nadir scan | Conical scan | Nadir | Conical scan | Nadir scan | Conical scan | Raster scan | Wide strip and thin circle combined scan |
| **Orbit parameters** | | | | | | | | |
| Altitude (km) | 595 | 407 | 1 336 | 665.96 | 830 | 830 | 35 800 | 35 800 |
| Inclination (degree) | 97.79 | 65 | 66 | 98.06 | 98.7 | 98.7 | N/A | N/A |
| Eccentricity | 0.001 | 0 | 0 | 0.0015 | 0.001 | 0.001 | N/A | N/A |
| Repeat period | 9 days/30 min (single satellite/constellation) | 43.5 days | 9.92 days | 3 days | 29 days | 29 days | N/A | N/A |
| **Sensor antenna parameters** | | | | | | | | |
| Number of beams | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Antenna size (m) | 0.16 | 1.22 | 1 | 2 | 0.35 | 0.76 | 3 | 5 |
| Maximum beam gain (dBi) | 46.6 | 54.3 | 61.0 | 57.2 | 43 | 60 | 72.1 | 73 |
| Polarization | QH/QV | H/V | Single Linear | V | QH/QV | V | V | V |
| −3 dB beamwidth (degree) | 0.8 | 0.37 | 0.18 | 0.23 × 0.30 | 1.15 | 0.33 | 0.04 | 0.04 |
| Instantaneous field of view | Nadir FOV: 8 km  (54 km²) Outer FOV: 16 × 35  (433 km²) | 6.3 × 4.1 km | 4 × 4 km | 4 km × 9 km | Nadir FOV: 17 km  (218 km²) Outer FOV: 55 × 28 km  (1 225 km²) | 7 × 12 km  (68 km²) | Nadir: 26 km | Nadir: 25 km |
| Off-nadir pointing angle (degree) | 54.4 | 45.4 | 3.4 along-track | 45.5 | ±49.31 cross-track | 44.8 | N/A | N/A |
| Incidence angle at Earth (degree) | 0 (nadir) 62.8 | 49.2 | 4.1 | 51.9 | 0 (nadir) 58.9 | 52.8 | N/A | N/A |

TABLE 45 (*end*)

|  | Sensor P7 | Sensor P8 | Sensor P9 | Sensor P10 | Sensor P11 | Sensor P12 | Sensor GSO-P1 | Sensor GSO-P2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Swath width (km) | 1900 | 819 | 4 | 1 398 | 2 220 | 1 700 | Full disk | 8 scan stripes, each strip 0.9×7.2, thin circle diameter 1.1 |
| Antenna efficiency |  |  | 0.42 |  | 0.6 | 0.6 | 0.60 | 0.60 |
| Beam dynamics | 1.1 s (45 rpm) | 32 rpm | N/A | 40 rpm | 2.254 s | 45 rpm (1.33 s) | Full disk: 45 min | General scan:  0.64/min  Local scan:  25.75 rpm |
| Sensor antenna pattern | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain (dBi) | 46.6 | 43.1 | N/A | 37.0 |  | N/A |  |  |
| Cold calibration angle (degrees re. satellite track) | 78° to 83° | 206.7° (CCW) | N/A | 118.7° | 78° to 83° | 165.5° to 203° | N/A |  |
| Cold calibration angle (degrees re. nadir direction) |  | 107.5° | N/A | 94.6° |  | N/A |  |  |
| **Sensor receiver parameters** | | | | | | | | |
| Sensor integration time (ms) | 2 | 3.6 | 125 | 2.5 | 13.7 | 1 to 8 | 10 | 10 |
| Channel bandwidth | 2 800 MHz centred at  165.5 GHz | 4 000 MHz centred at  166 GHz | 6 GHz centred at 166 GHz | 4 000 MHz centred at 165.5 GHz | 2 x 1 350 MHz centred at 165.5 ± 0.725 GHz | 2x1 425 MHz centred at  165.5 ± 0.73 GHz | 3 000 MHz centred at 165.5 GHz | 3 000 MHz centred at 165.5 GHz |
| **Measurement spatial resolution** | | | | | | | | |
| Horizontal resolution (km) |  | 4.1 | 4 | 4 |  |  | 39 (nadir) | 35 (nadir) |
| Vertical resolution (km) |  | 6.3 | 4 | 9 |  |  | 26 (nadir) | 25 (nadir) |

## 6.18 Typical parameters of passive sensors operating in the 174.8-191.8 GHz frequency band

The 174.8-191.8 GHz frequency band is essential for passive sensor measurements of N2O and O3, in addition towater vapour profiling. Tables 46 and 47 summarize the parameters of passive sensors that are or will be operating in the 174.8-191.8 GHz frequency band.

TABLE 46

EESS (passive) sensor characteristics operating in the 174.8-191.8 GHz frequency band

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sensor Q2 | Sensor Q3 | Sensor Q4 | Sensor Q5 | Sensor Q6 | Sensor Q7 | Sensor Q8 | Sensor Q9 | Sensor Q10 |
| Sensor type | Cross-track scan | Limb sounder | Mechanical nadir scan | Conical scan | Nadir scan | Nadir scan | Conical scan | Conical scan | Cross-track  nadir scan |
| **Orbit parameters** | | | | | | | | | |
| Altitude (km) | 705 | 705 | 824 | 835 | 867 | 822 | 830 | 407 | 595 |
| Inclination (degree) | 98.2 | 98.2 | 98.7 | 98.85 | 20 | 98.7 | 98.85 | 50 | 97.79 |
| Eccentricity | 0 | 0 | 0 | 0 | 0 | 0.001 | 0 | 0.003 | 0.001 |
| Repeat period | 16 days | 16 days | 9 days |  | 7 days | 29 days |  |  | 9 days/30 min (single satellite/constellation) |
| **Sensor antenna parameters** | | | | | | | | | |
| Number of beams | 1 | 1 | 96 earth fields per scan period | 6 | 6 | 1 (steerable in  90 earth fields per scan period) | 10 | 1 | 1 |
| Antenna size (m) | 0.219 | 1.6 (V) × 0.8 (H) | 0.127 | 0.65 | 0.2 | 0.22 | 1 | 0.7 | 0.16 |
| Maximum beam gain (dBi) | 45 | 65 | 43.9 | 58.5 | 49 | 44.8 | 63.8 | 60.6 | 47.5 |
| Polarization | Linear | V | QH | V | H | QV | V | See Table 33 | QH/QV |
| −3 dB beamwidth (degree) | 1.1 | 0.084 × 0.165 | 1.1 | 0.4 | 0.66 | 1.1 | 0.13 | 0.35 | 0.8 |
| Instantaneous field of view | 14 km | 4.5 km × 9 km | Nadir FOV: 15.8 km Outer FOV: 68.4 × 30 km | Outer FOV:  11 × 27 km | At nadir 10 km × 10 km At swath limit 14 km × 22 km | Nadir FOV: 16 km Outer FOV: 53 × 27 km | 3.6 km × 8.5 km  24 km2 | 5.8 km × 3.7 km | Nadir FOV: 8 km  (54 km²) Outer FOV: 16 × 35 km  (433 km²) |
| Off-nadir pointing angle | ±48.95° | N/A | ±52.725° cross-track | 53.3° | 42 | 49.4 | 53.3° | 46.1 | 54.4° |
| Incidence angle at Earth | 56.9° | N/A | N/A | 65° | 55 | 59 | 65° | 50° | 0° (nadir) 62.8° |

TABLE 46 (*cont.*)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sensor Q2 | Sensor Q3 | Sensor Q4 | Sensor Q5 | Sensor Q6 | Sensor Q7 | Sensor Q8 | Sensor Q9 | Sensor Q10 |
| Swath width | 1 650 km | N/A | 2 500 km | 1 600 km | 1 700 km | 2 193 km | 2 200 km | 800 km | 1 900 km |
| Antenna efficiency | 0.18 | 0.68 | 0.42 | 0.65 | 0.54 | 0.17 | 0.66 | 0.64 |  |
| Beam dynamics | 8/3 s scan period | Scans continuously in tangent height from the surface to ~92 km in  24.7 s 240 scans/ orbit | 8/3 s scan period cross-track | 2.5 scan period, clockwise | 1 revolution per 1.639 s | 8/3 s scan period cross-track | 2.5 scan period, counter clockwise | 30 rpm | 1.1 s (45 rpm) |
| Sensor antenna pattern | See Fig. 14 | Rec. ITU-R RS.1813 with minor mods (see NOTE in § 6.14) |  | Rec. ITU‑R RS.1813 |  |  | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 | Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain | 45 dB | N/A | 43.9 dBi | 49.5 dBi | N/A | 44.8 dBi | 51 dBi | 57.6 dBi | 47.5 dBi |
| Cold calibration angle (degrees re. satellite track) | 90° | N/A | 0 | 315° | N/A | −90° ± 3.9° | 315° | 180° | 78° to 83° |
| Cold calibration angle (degrees re. nadir direction) | 65° to 81° | N/A | 82.175 | 90° | N/A | 73.6 (66° to 81°) | 90° | 90° |  |
| **Sensor receiver parameters** | | | | | | | | | |
| Sensor integration time | 18 ms | 0.166 s | 18 ms | 5 ms | 7.34 ms | 18 ms | 5 ms | 2.08 ms | 2 ms |
| Channel bandwidth | 1 000 MHz centred at 183.31 ± 1.00 GHz  2 000 MHz centred at 183.31 ± 3.00 GHz  4 000 MHz centred at 183.31 ± 7.00 GHz | 1 250 MHz centred at 181.5987 and 183.3142 GHz  158 MHz centred at 177.2652 GHz  10 MHz centred at 183.3142 GHz | See Table 48 | 1.5 GHz centred at 183.31 ± 7 GHz  1.0 GHz centred at 183.31 ± 3 GHz  0.5 GHz centred at 183.31 ± 1 GHz | 6 channels from 200 MHz to 2 GHz centred at 183.31 GHz | 0.5 GHz centred at 183.311 ± 1 GHz  1.0 GHz centred at 183.311 ± 3 GHz  1.1 GHz centred at 190.311 ± 1 GHz | See Table 49 | See Table 50 | See Table 51 |

TABLE 46 (*end*)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sensor Q2 | Sensor Q3 | Sensor Q4 | Sensor Q5 | Sensor Q6 | Sensor Q7 | Sensor Q8 | Sensor Q9 | Sensor Q10 |
| **Measurement spatial resolution** | | | | | | | | | |
| Horizontal resolution (km) | 13.5 | 9 | 16 | 32 | 10 cross-track | 16 | 32 | 7.7 |  |
| Vertical resolution (km) | 13.5 | 4.5 | 16 | 32 | 10 | 16 | 32 | 5.8 |  |

TABLE 47

EESS (passive) sensor characteristics operating in the 174.8-191.8 GHz frequency band

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sensor Q11 | Sensor Q12 | Sensor Q13 | Sensor Q14 | Sensor Q15 | Sensor Q16 | Sensor  GSO-Q1 | Sensor  GSO-Q2 |
| Sensor type | Conical scan | Mechanical nadir scan | Conical scan | Nadir scan | Conical scan | Conical scan | Wide strip and thin circle combined scan | Raster scan |
| **Orbit parameters** | | | | | | | | |
| Altitude (km) | 407 | 550 | 665.96 | 830 | 830 | 830 | 35 800 | 35 800 |
| Inclination (degree) | 65 | 30 | 98.06 | 98.7 | 98.7 | 98.7 | N/A | N/A |
| Eccentricity | 0 | 0 | 0.0015 | 0.001 | 0.001 | 0.001 | N/A | N/A |
| Repeat period (days) | 43.5 | 18.6 | 3 | 29 | 29 | 29 | N/A | N/A |
| **Sensor antenna parameters** | | | | | | | | |
| Number of beams | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| Antenna size (m) | 1.22 | 0.083 | 2 | 0.35 | 0.76 | 0.255 | 5 | 3 |
| Maximum beam gain (dBi) | 53.8 | 41.6 | 57.9 | 43 | 56.9 | 52 | 73.2 | 72.1 |
| Polarization | V | H/V | V | QH/QV | V | V | See Table 55 | See Table 56 |
| −3 dB beamwidth | 0.37° | 1.69° | 0.23°×0.27° | 1.15° | 0.33° | 0.5° | 0.038° | 0.04° |

TABLE 47 (*cont.*)

EESS (passive) sensor characteristics operating in the 174.8-191.8 GHz frequency band

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sensor Q11 | Sensor Q12 | Sensor Q13 | Sensor Q14 | Sensor Q15 | Sensor Q16 | Sensor  GSO-Q1 | Sensor  GSO-Q2 |
| Instantaneous field of view | 5.8 × 3.8 km | Nadir IFOV: 16.2 km  Outer IFOV: 113.6 × 38.4 km | 4 km × 8 km | Nadir FOV: 17 km  (218 km²) Outer FOV: 55 × 28 km  (1 225 km²) | 7 × 12 km  (68 km²) | 11 × 18 km  (155 km²) | Nadir: 25 km | Nadir: 24 km |
| Off-nadir pointing angle | 45.4° | ±60° cross-track | 45.5° | ±49.31° cross-track | 44.8° | 44.7° / 45.2° | N/A | N/A |
| Incidence angle at Earth | 49.2° | ≤ 70.2° | 51.9° | 0 (nadir) 58.9° | 52.8° | 52.7° | N/A | N/A |
| Swath width | 819 km | 2 480 km | 1 398 km | 2 220 km | 1 700 km | 1 700 km | 8 scan stripes, each strip 0.9×7.2, thin circle diameter 1.1 | Full disk |
| Antenna efficiency |  | 0.57 |  | 0.60 | 0.6 | 0.6 | 0.23 | 0.49 |
| Beam dynamics | 32 rpm | 2 s scan period | 40 rpm | 2.254 s | 45 rpm (1.33 s) | 45 rpm  (1.33 s) | General scan:  0.64/min  Local scan:  25.75 rpm | Full disk: 45 min |
| Sensor antenna pattern | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 | See Rec. ITU‑R RS.1813 |
| Cold calibration ant. gain | 43.9 dBi | 41.6 dBi | 38.1 dBi |  |  | 44 dBi |  |  |
| Cold calibration angle (degrees re. satellite track) | 206.7° (CCW) | 0° | 118.7° | 78° to 83° | 165.5° to 203° | 130° to 135° |  | N/A |
| Cold calibration angle (degrees re. nadir direction) | 107.5° | 120° | 94.6° |  |  |  |  |  |

TABLE 47 (*end*)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sensor Q11 | Sensor Q12 | Sensor Q13 | Sensor Q14 | Sensor Q15 | Sensor Q16 | Sensor  GSO-Q1 | Sensor  GSO-Q2 |
| **Sensor receiver parameters** | | | | | | | | |
| Sensor integration time (ms) | 3.6 | 8.3 | 2.5 | 13.7 | 1 to 8 | 2 to 3 | 10 | 10 |
| Channel bandwidth | 2 000 MHz centred at  176.31,  180.31,  186.31,  and 190.31 GHz | 2 000 MHz centred at 184.41, 186.51, and 190.31 GHz | 2 000 MHz centred at 183.31 ± 3.00 GHz  2 000 MHz centred at 183.31 ± 7.00 GHz | See Table 52 | See Table 53 | See Table 54 | See Table 55 | See Table 56 |
| **Measurement spatial resolution** | | | | | | | | |
| Horizontal resolution (km) | 3.8 | 16.2 | 4 |  |  |  | 25 (nadir) | 36 (nadir) |
| Vertical resolution (km) | 5.8 | 16.2 | 8 |  |  |  | 25 (nadir) | 24 (nadir) |

FIGURE 14

Sensor Q2 antenna pattern for the 174.8 and 191.8 GHz frequency range

Chart, histogram

Description automatically generated

TABLE 48

Sensor Q4 passive sensor characteristics for channels between 174.8 and 191.8 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) | Polarization |
| 183.31 ± 4.5 | 2 000 | QH |
| 183.31 ± 1.8 | 1 000 | QH |
| 190.31 | < 2 200 | V |

TABLE 49

Sensor Q8 passive sensor characteristics for channels between 174.8 and 191.8 GHz

|  |  |
| --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) |
| 183.31 ± 7 | 2000 |
| 183.31 ± 4.5 | 2000 |
| 183.31 ± 3 | 1000 |
| 183.31 ± 1.8 | 1000 |
| 183.31 ± 1 | 500 |

TABLE 50

Sensor Q9 passive sensor characteristics for channels between 174.8 and 191.8 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) | Polarization |
| 183.31 ± 2.0 | 1 500 | V |
| 183.31 ± 3.4 | 1 500 | V |
| 183.31 ± 7.0 | 2 000 | V |

TABLE 51

Sensor Q10 passive sensor characteristics for channels between 174.8 and 191.8 GHz

|  |  |
| --- | --- |
| Frequency  (GHz) | Bandwidth (MHz) |
| 176.311 | 2 000 |
| 178.811 | 2 000 |
| 180.311 | 1 000 |
| 181.511 | 1 000 |
| 182.311 | 500 |

TABLE 52

Sensor Q14 passive sensor characteristics for channels between 174.8 and 191.8 GHz

|  |  |
| --- | --- |
| Frequency  (GHz) | Bandwidth (MHz) |
| 183.311 ± 7.0 | 2 × 2 000 |
| 183.311 ± 4.5 | 2 × 2 000 |
| 183.311 ± 3.0 | 2 × 1 000 |
| 183.311 ± 1.8 | 2 × 1 000 |
| 183.311 ± 1.0 | 2 × 500 |

TABLE 53

Sensor Q15 passive sensor characteristics for channels between 174.8 and 191.8 GHz

|  |  |
| --- | --- |
| Frequency  (GHz) | Bandwidth (MHz) |
| 183.31 ± 7.0 | 2 × 2 000 |
| 183.31 ± 6.1 | 2 × 1 500 |
| 183.31 ± 4.9 | 2 × 1 500 |
| 183.31 ± 3.4 | 2 × 1 500 |
| 183.31 ± 2.0 | 2 × 1 500 |

TABLE 54

Sensor Q16 passive sensor characteristics for channels between 174.8 and 191.8 GHz

|  |  |
| --- | --- |
| Frequency  (GHz) | Bandwidth (MHz) |
| 183.31 ± 7.0 | 2 × 2 000 |
| 183.31 ± 3.4 | 2 × 1 500 |
| 183.31 ± 2 | 2 × 1 500 |

TABLE 55

Sensor GSO-Q1 passive sensor characteristics for channels between 174.8 and 191.8 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) | Polarization |
| 183.31 ± 7 | 4 000 | H |
| 183.31 ± 4.5 | 4 000 | H |
| 183.31 ± 3 | 2 000 | H |
| 183.31 ± 1.8 | 2 000 | H |
| 183.31 ± 1 | 1 000 | H |

TABLE 56

Sensor GSO-Q2 passive sensor characteristics for channels between 174.8 and 191.8 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) | Polarization |
| 183.31 ± 1.0 | 500 | H |
| 183.31 ± 1.8 | 1 000 | H |
| 183.31 ± 3.0 | 1 000 | H |
| 183.31 ± 4.5 | 2 000 | H |
| 183.31 ± 7.0 | 2 000 | H |

## 6.19 Typical parameters of passive sensors operating in the 200-209 GHz frequency band

Table 57 summarizes the parameters of passive sensors that are or will be operating in the 200‑209 GHz frequency band.

TABLE 57

EESS (passive) sensor characteristics operating in the 200-209 GHz frequency band

|  | Sensor S1 | Sensor S2 |
| --- | --- | --- |
| Sensor type | Mechanical nadir scan | Limb sounder |
| **Orbit parameters** |  | |
| Altitude (km) | 550 | 705 |
| Inclination (degree) | 30 | 98.2 |
| Eccentricity | 0 | 0 |
| Repeat period (days) | 18.6 | 16 |
| **Sensor antenna parameters** |  | |
| Number of beams | 1 | 1 |
| Antenna size (m) | 0.083 | 1.6 (V) × 0.8 (H) |
| Maximum beam gain (dBi) | 44.1 | 65 |
| Polarization | H/V | V |
| −3 dB beamwidth (degree) | 1.64 | 0.078 × 0.152 |
| Instantaneous field of view (km) | Nadir IFOV: 15.7  Outer IFOV: 110.2 × 37.2 | 4.1 × 8.0 |
| Off-nadir pointing angle | ±60° cross-track | N/A |
| Incidence angle at Earth (degree) | ≤ 70.2 | N/A |
| Swath width (km) | 2 480 | N/A |
| Antenna efficiency | 0.81 | 0.55 |
| Beam dynamics | 2 s scan period | Scans continuously in tangent height from the surface to ~92 km in 24.7 s, 240 scans/orbit |
| Sensor antenna pattern | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 with minor mods(see NOTE in § 6.14) |
| Cold calibration ant. gain (dBi) | 44.1 | N/A |
| Cold calibration angle (degrees re. satellite track) | 0° | N/A |
| Cold calibration angle (degrees re. nadir direction) | 120° | N/A |
| **Sensor receiver parameters** |  | |
| Sensor integration time | 8.3 ms | 0.166 s |
| Channel bandwidth | 2 000 MHz  centred at 204.80 GHz | 1 250 MHz centred at 200.9798, 204.3566, and 206.1367 GHz |
| **Measurement spatial resolution** |  | |
| Horizontal resolution (km) | 15.7 | 8.0 |
| Vertical resolution (km) | 15.7 | 4.1 |

## 6.20 Typical parameters of passive sensors operating in the 226-252 GHz frequency range

This frequency range is particularly important in providing information to the weather and climate models on ice clouds, especially cirrus clouds, cloud ice water path and cloud ice effective radius, all in support of numerical weather prediction (NWP) and nowcasting. In particular the band is important for measuring cloud ice water paths and cirrus clouds and it is key to estimate the cloud ice content. This is a quasi-window band which allows measuring radiances at both horizontal and vertical polarisations through the atmosphere due to minimum atmospheric absorption compared to the neighbouring bands, allowing to retrieve information on different ice crystal habits.

Tables 58 and 59 summarize the parameters of passive sensors that are or will be operating in the frequency range of 226 and 252 GHz.

TABLE 58

EESS (passive) sensor characteristics operating between 226 and 252 GHz

|  |  |  |
| --- | --- | --- |
|  | Sensor T1 | Sensor T2 |
| Sensor type | Conical scan | Limb sounder |
| **Orbit parameters** |  | |
| Altitude (km) | 830 | 705 |
| Inclination (degree) | 98.7 | 98.2 |
| Eccentricity | 0.001 | 0 |
| Repeat period (days) | 29 | 16 |
| **Sensor antenna parameters** |  | |
| Number of beams | 1 | 1 |
| Antenna size (m) | 0.255 | 1.6 (V) × 0.8 (H) |
| Maximum beam gain (dBi) | 52 | 67.5 |
| Polarization | V and H | H |
| −3 dB beamwidth (degree) | 0.5 | 0.060 × 0.123 |
| Instantaneous field of view (km) | 11 × 18  (155 km²) | 3.2 × 6.4 |
| Off-nadir pointing angle (degree) | 44.7 | N/A |
| Incidence angle at Earth (degree) | 52.7 | N/A |
| Swath width (km) | 1 700 | N/A |
| Antenna efficiency | 0.64 | 0.69 |
| Beam dynamics | 45 rpm (1.33 s) | Scans continuously in tangent height from the surface to ~92 km in 24.7 s, 240 scans/orbit |
| Sensor antenna pattern | Rec. ITU-R RS.1813 | Rec. ITU-R RS.1813 with minor mods (see NOTE in § 6.14) |
| Cold calibration ant. gain (dBi) | 47 | N/A |
| Cold calibration angle (degrees re. satellite track) | 130° to 135° | N/A |
| Cold calibration angle (degrees re. nadir direction) |  | N/A |
| **Sensor receiver parameters** |  | |
| Sensor integration time | 2 to 3 ms | 0.166 s |
| Channel bandwidth | See Table 60 | See Table 61 |
| **Measurement spatial resolution** |  | |
| Horizontal resolution (km) |  | 6.4 |
| Vertical resolution (km) |  | 3.2 |

TABLE 59

EESS (passive) sensor characteristics operating between 226 and 252 GHz

|  | Sensor T3 (MWS) |
| --- | --- |
| Sensor type | Nadir Scan |
| **Orbit parameters** | |
| Altitude (km) | 830 |
| Inclination (degree) | 98.7 |
| Eccentricity | 0.001 |
| Repeat period (days) | 29 |
| **Sensor antenna parameters** | |
| Number of beams | 1 |
| Antenna size (m) | 0.35 |
| Maximum beam gain (dBi) | 56 |
| Polarization | QV |
| −3 dB beamwidth (degree) | 1.15° |
| Instantaneous field of view (km) | Nadir FOV: 17  (218 km²) Outer FOV: 55 × 28  (1 225 km²) |
| Off-nadir pointing angle (degree) | ±49.31° cross-track |
| Incidence angle at Earth (degree) | 0 (nadir) 58.9 |
| Swath width (km) | 2 220 |
| Antenna efficiency | 0.60 |
| Beam dynamics (s) | 2.254 |
| Sensor antenna pattern | Rec. ITU-R RS.1813 |
| Cold calibration ant. gain (dBi) |  |
| Cold calibration angle (degrees re. satellite track) | 78° to 83° |
| Cold calibration angle (degrees re. nadir direction) |  |
| Number of beams |  |
| **Sensor receiver parameters** | |
| Sensor integration time (ms) | 13.7 |
| Channel bandwidth | 2 000 MHz centred at 229 GHz |
| **Measurement spatial resolution** | |
| Horizontal resolution |  |
| Vertical resolution |  |

TABLE 60

Sensor T1 passive sensor characteristics for channels between 239 and 248 GHz

|  |  |  |
| --- | --- | --- |
| Centre frequency  (GHz) (see NOTE below) | Frequency range (GHz) | Channel bandwidth  (MHz) |
| 243.2 ± 2.5 | 239.2-242.2 244.2-247.2 | 2 × 3 000 |
| NOTE – The T1 instrument has also multiple channels in bands above 275 GHz (three channels around 325 GHz, three channels around 448 GHz and one channel at 664 GHz). | | |

TABLE 61

Sensor T2 passive sensor characteristics for channels between 231 and 248 GHz

|  |  |
| --- | --- |
| Centre frequency  (GHz) | Channel bandwidth  (MHz) |
| 231.86 | 500 |
| 232.46 | 500 |
| 233.9515 | 1 250 |
| 234.86 | 500 |
| 235.7151 | 10 |
| 235.7151 | 1 250 |
| 236.66 | 500 |
| 242.66 | 500 |
| 244.46 | 500 |
| 246.86 | 500 |
| 247.46 | 500 |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. \* Radiocommunication Study Group 7 made editorial amendments to this Recommendation in the year 2023 in accordance with Resolution ITU-R 1. [↑](#footnote-ref-1)
2. The ‘vadose zone’ is the portion of Earth between the land surface and the zone of saturation which extends from the top of the ground surface to the water table. [↑](#footnote-ref-2)