



**Recommendation ITU-R RS.2017-0**  
(08/2012)

**Performance and interference criteria  
for satellite passive remote sensing**

**RS Series**  
**Remote sensing systems**

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<b>RS</b>	<b>Remote sensing systems</b>
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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.2017-0\*

**Performance and interference criteria for satellite passive remote sensing**

(2012)

**Scope**

This Recommendation provides information on the performance and interference criteria for satellite passive remote sensing of the Earth and its atmosphere for microwave passive sensors.

The ITU Radiocommunication Assembly,

*considering*

- a) that certain frequency bands, including some absorption bands of atmospheric gases (e.g. O<sub>2</sub> (oxygen) and H<sub>2</sub>O (water vapour)), have been allocated for spaceborne passive microwave remote sensing;
- b) that some of these bands are also allocated to other radiocommunication services;
- c) that performance criteria are a necessary prerequisite to the establishment of interference and sharing criteria;
- d) that surface brightness temperature, the atmospheric temperature at points along a path and absorption coefficients can be determined from measurements of the sensor antenna temperature,  $T_A$ ;
- e) that the surface brightness temperature and the absorption coefficients, in turn, depend upon the physical properties of the surface or atmosphere that are to be sensed;
- f) that studies have established measurement sensitivity requirements;
- g) that interference criteria should be compatible with performance objectives;
- h) that interference criteria are a necessary prerequisite to the establishment of sharing criteria;
- j) that interference criteria can be stated in terms of interference power within a reference bandwidth;
- k) that passive microwave remote sensing is performed in absorption bands to obtain important three-dimensional atmospheric data that are used in particular to initialize numerical weather prediction (NWP) models;
- l) that studies have established that measurements in absorption bands are extremely vulnerable to interference because, in general, there is no possibility to detect and to reject data that are contaminated by interference, and because propagation of undetected contaminated data into NWP models may have a destructive impact on the reliability/quality of weather forecasting;
- m) that three-dimensional measurements of atmospheric temperature or gas concentration are performed in the absorption bands including those in the range 52.6-59.3 GHz, 115.25-122.25 GHz, 174.8-191.8 GHz, as well as the auxiliary window channels at 23.6-24 GHz, 31.3-31.8 GHz, 50.2-50.4 GHz and 86-92 GHz;
- n) that performance requirements for passive sensors can be stated in terms of measurement sensitivity,  $\Delta T_e$ , and availability, measured at the satellite, assuming that degradation from other elements in the system will be small;

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\* Radiocommunication Study Group 7 made editorial amendments to this Recommendation in the year 2017 in accordance with Resolution ITU-R 1.

- o) that the sensitivities of radiometric passive sensors are generally expressed as a temperature differential,  $\Delta T_e$ , given by:

$$\Delta T_e = \alpha T_s / \sqrt{Bt} \quad \text{K}$$

where:

- $\Delta T_e$ : radiometric resolution (root-mean-square (r.m.s.) uncertainty in estimation of total system noise,  $T_s$ );
- $\alpha$ : receiver system constant;
- $T_s$ : system noise temperature (K) (antenna temperature and receiver noise temperature);
- $B$ : spectral resolution (of spectro-radiometer) or “reference bandwidth” of a single radiometric channel (Hz);
- $t$ : sensor integration time (s);

- p) that the radiometer threshold, or minimum discernible power change, is given by:

$$\Delta P = k \Delta T_e B \quad \text{W}$$

where  $k$  is Boltzmann’s constant =  $1.38 \times 10^{-23}$  J/K,

*recommends*

- 1** that the measurement sensitivities suitable for satellite passive remote sensing of the Earth’s land, oceans and atmosphere indicated in Table 1 should be used as performance criteria;
- 2** that in bands used for satellite passive remote sensing, the required minimum availability of passive sensor data for each band should be as specified in column 3 (Data availability) of Table 1;
- 3** that the permissible interference level for spaceborne passive sensors should be set at 20% of  $\Delta P$ ;
- 4** that permissible interference levels and reference bandwidths for the frequency bands preferred for satellite passive sensing of the Earth’s land, oceans and atmosphere as specified in Table 2 should be used in any interference assessment or sharing studies;
- 5** that the interference level in Table 2 should not be exceeded for more than a percentage of sensor viewing area or a percentage of measurement time as given in column 4 of Table 2.

TABLE 1

## Performance criteria for satellite passive remote sensing up to 1 000 GHz

Frequency band(s) (GHz)	Required $\Delta T_e$ (K)	Data availability <sup>(1)</sup> (%)	Scan mode (N, C, L) <sup>(2)</sup>
1.370-1.427	0.05	99.9	N, C
2.64-2.70	0.1	99.9	N
4.2-4.4	0.05	99.9	N, C
6.425-7.25	0.05	99.9	N, C
10.6-10.7	0.1	99.9	N, C
15.2-15.4	0.1	99.9	N, C
18.6-18.8	0.1	99.9	N, C
21.2-21.4	0.05	99.9	N
22.21-22.5	0.05	99.9	N
23.6-24	0.05	99.99	N, C
31.3-31.8	0.05	99.99	N, C
36-37	0.1	99.9	N, C
50.2-50.4	0.05	99.99	N, C
52.6-59.3	0.05	99.99	N, C
86-92	0.05	99.99	N, C
100-102	0.005	99	L
109.5-111.8	0.005	99	L
114.25-116	0.005	99	L
115.25-122.25	0.05/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
148.5-151.5	0.1/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
155.5-158.5 <sup>(4)</sup>	0.1	99.99	N, C
164-167	0.1/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, C, L
174.8-191.8	0.1/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, C, L
200-209	0.005	99	L
226-231.5	0.2/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
235-238	0.005	99	L
250-252	0.005	99	L
275-285.4	0.005	99	L
296-306	0.2/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
313.5-355.6	0.3/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, C, L
361.2-365	0.3/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
369.2-391.2	0.3/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
397.2-399.2	0.3/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
409-411	0.005	99	L
416-433.46	0.4/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
439.1-466.3	0.4/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, C, L

TABLE 1 (*end*)

Frequency band(s) (GHz)	Required $\Delta T_e$ (K)	Data availability <sup>(1)</sup> (%)	Scan mode (N, C, L) <sup>(2)</sup>
477.75-496.75	0.005	99	L
497-502	0.5/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
523-527	0.5	99.99	N
538-581	0.5/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
611.7-629.7	0.005	99	L
634-654	0.6/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
656.9-692	0.6/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, C, L
713.4-717.4	0.005	99	L
729-733	0.005	99	L
750-754	0.005	99	L
771.8-775.8	0.005	99	L
823.15-845.15	0.8/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, C, L
850-854	0.005	99	L
857.9-861.9	0.005	99	L
866-882	0.8	99.99	C
905.17-927.17	0.9/0.005 <sup>(3)</sup>	99.99/99 <sup>(3)</sup>	N, L
951-956	0.005	99	L
968.31-972.31	0.005	99	L
985.9-989.9	0.005	99	L

<sup>(1)</sup> Data availability is the percentage of area or time for which accurate data is available for a specified sensor measurement area or sensor measurement time. For a 99.99% data availability, the measurement area is a square on the Earth of 2 000 000 km<sup>2</sup>, unless otherwise justified; for a 99.9% data availability, the measurement area is a square on the Earth of 10 000 000 km<sup>2</sup> unless otherwise justified; for a 99% data availability the measurement time is 24 h, unless otherwise justified.

<sup>(2)</sup> N: Nadir, Nadir scan modes concentrate on sounding or viewing the Earth's surface at angles of nearly perpendicular incidence. The scan terminates at the surface or at various levels in the atmosphere according to the weighting functions. L: Limb, Limb scan modes view the atmosphere "on edge" and terminate in space rather than at the surface, and accordingly are weighted zero at the surface and maximum at the tangent point height. C: Conical, Conical scan modes view the Earth's surface by rotating the antenna at an offset angle from the nadir direction.

<sup>(3)</sup> First number for nadir or conical modes and second number for microwave limb sounding applications.

<sup>(4)</sup> This band is needed until 2018 to accommodate existing and planned sensors.

TABLE 2

## Interference criteria for satellite passive remote sensing up to 1 000 GHz

Frequency band(s) (GHz)	Reference bandwidth (MHz)	Maximum interference level (dBW)	Percentage of area or time permissible interference level may be exceeded <sup>(1)</sup> (%)	Scan mode (N, C, L) <sup>(2)</sup>
1.370-1.427	27	-174	0.1	N, C
2.64-2.70	10	-176	0.1	N
4.2-4.4	200	-166	0.1	N, C
6.425-7.25	200	-166	0.1	N, C
10.6-10.7	100	-166	0.1	N, C
15.2-15.4	50	-169	0.1	N, C
18.6-18.8	200	-163	0.1	N, C
21.2-21.4	100	-169	0.1	N
22.21-22.5	100	-169	0.1	N
23.6-24	200	-166	0.01	N, C
31.3-31.8	200	-166	0.01	N, C
36-37	100	-166	0.1	N, C
50.2-50.4	200	-166	0.01	N, C
52.6-59.3	100	-169	0.01	N, C
86-92	100	-169	0.01	N, C
100-102	10	-189	1	L
109.5-111.8	10	-189	1	L
114.25-116	10	-189	1	L
115.25-122.25	200/10 <sup>(3)</sup>	-166/-189 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
148.5-151.5	500/10 <sup>(3)</sup>	-159/-189 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
155.5-158.5 <sup>(4)</sup>	200	-163	0.01	N, C
164-167	200/10 <sup>(3)</sup>	-163/-189 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, C, L
174.8-191.8	200/10 <sup>(3)</sup>	-163/-189 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, C, L
200-209	3	-194	1	L
226-231.5	200/3 <sup>(3)</sup>	-160/-194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
235-238	3	-194	1	L
250-252	3	-194	1	L
275-285.4	3	-194	1	L
296-306	200/3 <sup>(3)</sup>	-160/-194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
313.5-355.6	200/3 <sup>(3)</sup>	-158/-194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, C, L
361.2-365	200/3 <sup>(3)</sup>	-158/-194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
369.2-391.2	200/3 <sup>(3)</sup>	-158/-194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L



TABLE 2 (*end*)

Frequency band(s) (GHz)	Reference bandwidth (MHz)	Maximum interference level (dBW)	Percentage of area or time permissible interference level may be exceeded <sup>(1)</sup> (%)	Scan mode (N, C, L) <sup>(2)</sup>
397.2-399.2	200/3 <sup>(3)</sup>	−158/−194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
409-411	3	−194	1	L
416-433.46	200/3 <sup>(3)</sup>	−157/−194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
439.1-466.3	200/3 <sup>(3)</sup>	−157/−194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, C, L
477.75-496.75	3	−194	1	L
497-502	200/3 <sup>(3)</sup>	−156/−194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
523-527	200	−156	0.01	N
538-581	200/3 <sup>(3)</sup>	−156/−194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
611.7-629.7	3	−194	1	L
634-654	200/3 <sup>(3)</sup>	−155/−194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
656.9-692	200/3 <sup>(3)</sup>	−155/−194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, C, L
713.4-717.4	3	−194	1	L
729-733	3	−194	1	L
750-754	3	−194	1	L
771.8-775.8	3	−194	1	L
823.15-845.15	200/3 <sup>(3)</sup>	−154/−194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, C, L
850-854	3	−194	1	L
857.9-861.9	3	−194	1	L
866-882	200	−154	0.01	C
905.17-927.17	200/3 <sup>(3)</sup>	−153/−194 <sup>(3)</sup>	0.01/1 <sup>(3)</sup>	N, L
951-956	3	−194	1	L
968.31-972.31	3	−194	1	L
985.9-989.9	3	−194	1	L

<sup>(1)</sup> For a 0.01% level, the measurement area is a square on the Earth of 2 000 000 km<sup>2</sup>, unless otherwise justified; for a 0.1% level, the measurement area is a square on the Earth of 10 000 000 km<sup>2</sup> unless otherwise justified; for a 1% level, the measurement time is 24 h, unless otherwise justified.

<sup>(2)</sup> N: Nadir, Nadir scan modes concentrate on sounding or viewing the Earth's surface at angles of nearly perpendicular incidence. The scan terminates at the surface or at various levels in the atmosphere according to the weighting functions. L: Limb, Limb scan modes view the atmosphere "on edge" and terminate in space rather than at the surface, and accordingly are weighted zero at the surface and maximum at the tangent point height. C: Conical, Conical scan modes view the Earth's surface by rotating the antenna at an offset angle from the nadir direction.

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