



Report ITU-R RA.2188-1
(10/2022)

**Power flux-density and e.i.r.p. levels
potentially damaging to radio
astronomy receivers**

RA Series
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Foreword

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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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***Note:** This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

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Power flux-density and e.i.r.p. levels potentially damaging to radio astronomy receivers

(Question ITU-R 145/7)

(2010-2022)

1 General explanation of concerns

Telescopes of the radio astronomy service (RAS) are designed to achieve strong isolation from ambient radiation and have been placed in remote locations whenever possible, to enable detection of cosmic phenomena wherever they may occur on the sky (although typically above about 5-degree elevation). However, both cosmic and man-made signals which cross the main beam are received with very high gain, owing to the large apertures needed to detect weak cosmic signals. For man-made signals the combination of high receiving gain and high incident signal strength could suffice to permanently degrade the performance of a RAS receiver, or perhaps even destroy it. This Report describes the means by which the corresponding incident power flux-density (pfd) may be ascertained.

The nature of the possible damage of concern to the RAS is not necessarily complete burnout of the receiver input stages. Because the RAS has large investments in antenna collecting area it is necessary to use this most efficiently, so a long-term degradation of even 10% in the noise figure of a receiver input would be sufficient to warrant replacement. Servicing of input stages is time-consuming and expensive since cycling of cryogenic systems is involved and recent RAS instruments employ arrays of antennas and/or receiving elements numbering anywhere from tens to hundreds.

Receivers used by the RAS are designed to provide the lowest possible receiver noise temperatures to allow study of the widest possible range of astronomical signal levels. Receiver input stages are coupled directly to the antenna outputs without input filters or other components, since even very small losses can introduce significant levels of thermal noise. The amplifiers and mixers used in the input stages for high frequency observations necessarily require components with very small physical dimensions which limit their power-handling capacity.

Because the amplifier or mixer in RAS receivers is usually fed directly from the output of the antenna feed, damage can occur even if the transmitter frequency does not fall within the receiver passband. On the low-frequency side the damage is generally confined by waveguide cut off at the throat of the horn to frequencies no less than 0.6 times the centre frequency of the feed horn. On the high side the power delivered to the receiver by a horn feed will decrease by approximately 6 dB per octave as the beamwidth of the feed decreases, and by a further factor depending on the response of the coupling circuitry from the feed to the amplifier or mixer input. This second factor will depend upon the particular design of the coupling.

Two main types of low-noise input stages are presently used by the RAS, corresponding approximately to observations at frequencies below or above 90 GHz, and these are discussed separately below. The Heterostructure Field-Effect Transistor (HFET) low-noise transistor amplifiers which are used up to 90 GHz (and which are the only kind used below 70 GHz) are somewhat more susceptible to damage than the superconducting Superconductor-Insulator-Superconductor (SIS) mixers which are mainly employed above 90 GHz.