IOT Systems, LLC®

Ka-Band Radiometer Systems

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Radiometers are highly sensitive receivers designed to measure thermal electromagnetic emission from material media. In radiowave propagation measurements and other ground-based atmosphere probing, radiometers collect thermal energy emanating from a given direction in space. The amount of thermal energy received (usually measured as sky noise temperature) can be used to derive the propagation impairments present along the direction of observation. In satellite communications applications, radiometers routinely collect propagation data-chiefly signal attenuation due to rain, clouds, and gaseous components in the atmosphere. In addition, radiometers are useful in conducting in-orbit performance verification tests on geostationary satellites.

IOT Systems, LLC has substantial experience through our COMSAT Laboratories heritage in designing and fabricating radiometers, as well as interpreting the data collected. Over the last 15 years, IOT Systems/COMSAT-built radiometers have been in operation throughout the world, including some in inhospitable environments in Africa, South America, and southeast Asia. Their operating frequencies have ranged from 11 to 30 GHz, and their design reliability and ruggedness have been amply demonstrated. In addition, IOT Systems, LLC regularly updates the radiometer design to take advantage of advances in RF and electronic component technology.

The IOT Systems, LLC Ka-Band Radiometer System is mounted in a standard antenna and consists of the antenna and an RF down-converter. The wideband IF noise signal from the down-converter is fed to a signal integrator/detector, the output of which is sent to a controller/signal processor located inside the down-converter. The output of the controller represents the sky noise temperature measured along the antenna boresight. Although antenna sidelobes also contribute to the overall measured temperature, their contribution can be accurately estimated through a system calibration.

The measured noise temperature can be directly translated into an estimated path attenuation using the relationship:

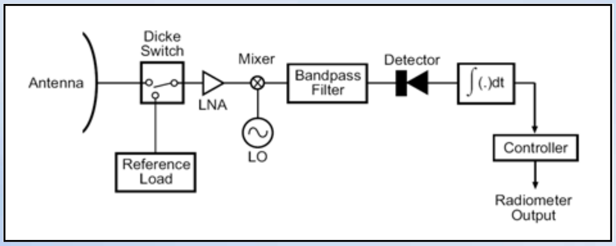
$$A = 10 \log \left[\frac{T_m}{(T_m - T_s)} \right] \text{ (dB)}$$

where:

A = path attenuation

T_m = a constant in the range of 270 to 290 K and specific to the location of the measurement

T_s = measured sky noise temperature.



IOT Systems Ka-Band Radiometer System Block Diagram

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IOT Systems, LLC is a complete satellite services company continuing the mission begun over 40 years ago with the launch of Early Bird: fostering the growth of the commercial communications satellite industry.

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The radiometer uses the Dicke principle, which minimizes the effect of gain variations in the receiver chain. In this implementation, the antenna temperature is compared with a reference load maintained at a constant temperature. Because system gain variations affect both temperature readings, the ratio of the two readings eliminates gain variations. The RF electronics are maintained at a near-constant temperature in order to keep any change in the overall system-noise temperature from affecting the measurement. A high degree of temperature regulation inside the RF box is achieved using Peltier-effect heat pumps. These are controlled by the radiometer controller on the basis of readouts from several temperature sensors strategically placed inside the RF box.

Switching between the input ports in the Dicke operation requires a coherent detection in the baseband processor. The sensitivity of the radiometer is expressed by:

$$\Delta T = 2\,(T_s + T_r)\frac{1}{\sqrt{B\tau}}$$

where:

ΔT	= minimum detectable change in input temperature
T_s	= antenna temperature
T_r	= reference load temperature
B	= detection bandwidth
τ	= detector integration time.

The design uses a bandwidth of about 250 MHz and a selectable integration time ranging from 0.1 to 10 seconds.

Users conduct noise processing and system control on a PC that displays the normal operating values for sky noise temperature, path attenuation, ambient temperature, and reference-load temperatures. With a serial interface, users select parameters such as integration time and medium temperature.

For satisfactory operation, the radiometer requires brief bimonthly manual calibration. This calibration uses external hot and cold loads, where the hot load temperature is the ambient temperature and the cold load temperature is maintained at approximately 80 K by immersing the load in liquid nitrogen.

IOT Systems Ka-Band Radiometer System Specifications:

❑ **Antenna**	1.2-m diameter, offset-fed reflector
❑ **Operating Frequency**	20/30 GHz
❑ **Polarization**	Linear
❑ **Measurement Mode**	Dicke switched, Y factor
❑ **IF Bandwidth**	≥250 MHz
❑ **Temperature Regulation Inside RF Box**	±2°C
❑ **Radiometer Integration Time**	0.1 to 10 s, selectable
❑ **Sensitivity**	<0.3 K
❑ **Relative Humidity**	0–100% condensing
❑ **Weight**	5.44 kg (12 lb) (excluding antenna)
❑ **Measurement Range**	0–400K
❑ **Measurement Resolution**	Full-scale/2048
❑ **Measurement Accuracy**	±2 K
❑ **Data Sampling Rate**	3 Hz
❑ **External Interfaces**	RS-485 LCD Display
❑ **Calibration Method**	Tip curve (at installation) Hot/cold (bimonthly)
❑ **Power Consumption**	200 W 110/220 V
❑ **Operating Temperature Range**	-30° to +55°C
❑ **Altitude**	3.05 km (10,000 ft) max

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