VII-4. SUBMILLIMETER BROADBAND POWER-MEASURING DETECTOR

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A broadband thermal power-measuring detector has been developed for the 300 to 3000 GHz (1 mm to 100 micron) band, with indications that it is useful over a significantly larger frequency interval. Exploratory detector measurements have so far been made at frequencies from 50 GHz (6 mm) to 20, 000 GHz (15 microns).

Emphasis in the development was on filling a need, in this relatively unexplored region of the spectrum, for a power-measuring detector combining room temperature operation, microwave sensitivity, ruggedness, amenability to absolute calibration, and operation over at least a 10 to 1 frequency band. Calibrated test results, measured at 70 GHz, were as follows:

Responsivity	240 volts/watt
Minimum Detectable Signal	10^{-8} watt for t 1 sec.
Dynamic Range	50 dB (10^{-8} to 10^{-3} watt)
Voltage Output	Linear with power input

The detector is operable with coherent or incoherent radiation, and by means of adapters, can be used with either oversize rectangular waveguide, free-space transmission (such as used in spectrometers), conical light pipe, etc. Although various detection mechanisms were considered (photodetectors, Golay cell, crystal diode, fine-wire bolometers, and thermal detectors), a thermal detector was chosen in order to obtain broadband operation, absolute calibration, multimode operation, etc.

Figure 1 shows the detector. The input waveguide adapter shown is an RG-98 (50 to 75 GHz) rectangular guide, which is 20 times oversize at 1000 GHz (300 microns). Broadband operation dictates the use of a distributed device. The minimum dimensions of the detector are determined by the diameter of the Airy disk, that is, the diffraction-limited area of the beam at the longest wavelength, given by:

$$D = 1.22 \; F \lambda$$

where, D = diameter at first minima, F = f/number of optics employed, and λ = wavelength. Accordingly, a detector with an area of 3 x 3 mm is a good compromise for maximum sensitivity.

One of the prime advantages of a broadband thermal detector is that it can also be tested outside the submillimeter band, at millimeter and far-infrared wavelengths where more powerful sources and calibrated power-measuring devices are available. Thus, the detector has also been checked at 70 GHz, where it has a VSWR of 1.06, against a fine-wire bolometer, using a coherent klystron source (Figure 2). As Figure 2 indicates, the detector has a responsivity of 240 v/w, a minimum detectable signal near 10^{-8} watt for an integration time near 1 second, and a linear dynamic range of 50 dB.

The detector itself consists of a thin-film absorber mounted on dielectric substrate in close thermal contact with a thermistor bolometer element. The slanted construction assures a good impedance match at millimeter and submillimeter wavelengths. A second (matched) thermistor serves to compensate for ambient temperature changes. The power absorber and associated substrate were optimized for operation over the 300 to 3000 GHz band. In view of the lack of available data on submillimeter material properties, measurements were made on absorptivity and reflectivity of dielectrics (such as alumina and beryllia), and thin-film absorbers using a far-infrared spectrophotometer. This data will be discussed and performance data on the detector output at submillimeter wavelengths will be reported.

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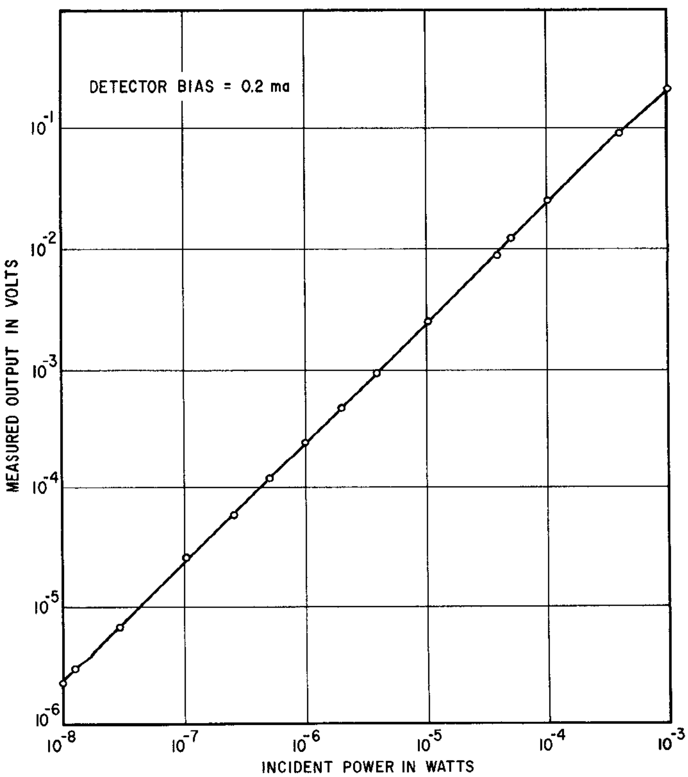

Figure 1. Submillimeter Broad-Band Power-Measuring Detector

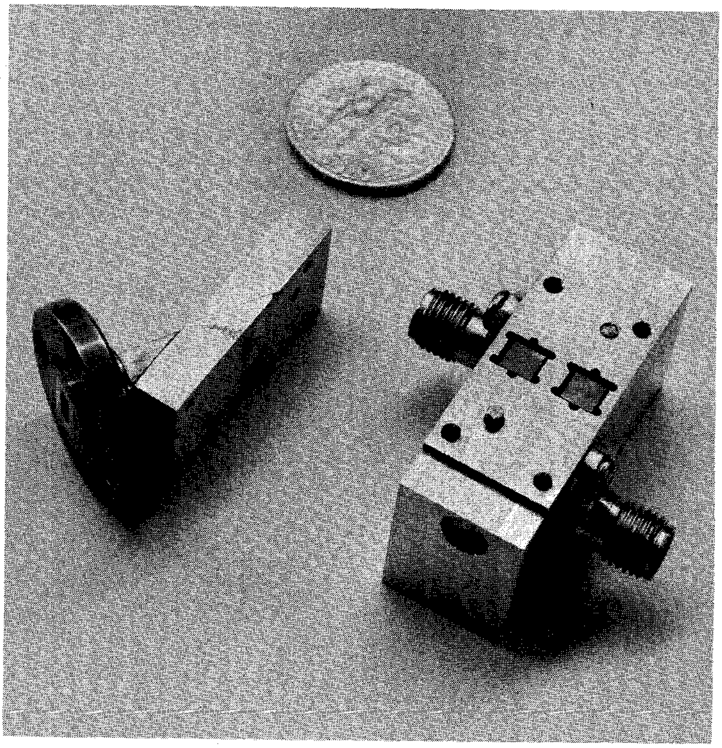

Figure 2. Detector Response vs Power Level (Measured at 70 GHz)