

An RF Radiation Detector

THIS INVENTION relates to an RF radiation detector and more particularly to an RF radiation detector which is compact, inexpensive, simple, battery-less and highly sensitive.

Radio frequency (RF) radiation sources are commonplace. For example, microwave ovens, cellular telephones, radio and television transmitters and most electrical or electronic appliances emit some form of RF radiation. Excessive exposure to RF radiation can comprise a health risk so most electrical appliances have to conform to specific regulations which set a specific threshold for the amount of RF radiation allowed to leak or be emitted from the appliance.

Existing RF detectors are bulky items which require a power source such as a battery to drive the detector circuitry. Examples of such devices are disclosed in US-A-3,746,824 and US-A-3,748,424. Microwave leakage detectors are disclosed in US-A-4,032,910 and US-A-4,338,595. However, these microwave leakage detectors lack sensitivity, only being able to detect emissions in the order of 1 to 4mW/cm².

Canadian Patent Application No. 2,113,850 discloses a highly directive cavity antenna system which offers sensitivity in the region of 0.1 mW/cm². However, owing to the highly directional antenna system and the large antenna size, such a system is impractical for detecting low frequency RF radiation.



It is an object of the present invention to provide an RF radiation detector which is compact, inexpensive, simple, battery-less and highly sensitive.

Accordingly, one aspect of the present invention provides an antenna for receiving RF radiation and producing an RF voltage; voltage magnification means to magnify the RF voltage; and a rectifying circuit to convert the magnified RF voltage received at the antenna to a DC voltage indicative of the level of radiation.

In order that the present invention may be more readily understood, embodiments thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 is a schematic diagram of an RF radiation detector embodying the present invention; and

FIGURE 2 is a schematic circuit diagram of the RF radiation detector of Figure 1.

Referring to Figure 1, an RF radiation detector embodying the present invention comprises an RF antenna 1 for receiving RF radiation and producing an RF voltage. The antenna 1 is connected to a rectifying circuit 2 which is, in turn, connected to an indicator 3 to provide an indication of the level of RF radiation.

The basic function of the rectifying circuit 2 is to magnify and convert the RF voltage produced by the antenna 1 into a usable DC voltage, the level of the DC voltage being indicative of the level of RF radiation received by the

antenna 1. In this manner, the indicator 3 is able to provide the indication of the level of RF radiation received by the antenna 1.

Referring to Figure 2 which shows the structure of the RF radiation detector of Figure 1 in more detail, it can be appreciated that the rectifying circuit 2 is supplemented with further circuitry to provide more than just means for converting the RF voltage received from the antenna 1 to a usable DC voltage.

In the example shown in Figure 2, the antenna 1 is a patch antenna which is connected to a matching circuit 4 for matching the reactance of the antenna 1 to that of the rectifying circuit 2. An external capacitor 5 is shunted between the matching circuit 4 and the rectifying circuit 2 and takes the form, in the example shown in Figure 2, of a length of microstrip. The rectifying circuit 2 itself comprises a charging capacitor 6 connected in series to ground through a zero bias Schottky diode 7. A further zero bias Schottky diode 8 is connected to the junction between the first Schottky diode 7 and the charging capacitor 6 such that the rectifying circuit 2 converts the RF voltage received from the antenna 1 to a usable DC voltage. In the example of Figure 2, the indicator 3 takes the form of a light emitting diode (LED) 9 connected to ground by a variable resistor 10. The LED 9 is placed across the rectifying circuit 2 as a load such that when the usable DC voltage produced by the rectifying circuit 2 exceeds a predetermined threshold, the LED 9 will illuminate. The particular threshold level can be set by adjustment of the variable resistor 10 located between the LED 9 and ground. Alternatively, the variable resistor 10 can be shunted across the LED 9 instead of being connected in series with LED 9. The variable resistor 10 thereby controls the sensitivity of the detector.

The respective components of the detector are mounted on or etched into an appropriate printed circuit board or substrate.

The provision of the external capacitor 5 shunting the rectifier circuit 2 provides a voltage magnification effect which thereby enhances the sensitivity of the rectifying circuit.

In the example shown in Figure 2, the particular components used comprise a printed circuit board material having a dielectric constant of 3.38. The DC blocking capacitor (charging capacitor 6) is 1 nF. The Schottky diodes 7,8 are HSMS-2852 and the light emitting diode 9 is an HLMP-K155. For maximum sensitivity, the variable resistor 10 shown in Figure 2 is short circuited. The detector is designed to operate at 2.45 GHz. With reference to the voltage magnification effect, the voltage across the external capacitance 5 would be in the order of five times the voltage across the antenna 1.

The example of the detector shown in Figure 2 is especially useful as an RF radiation detector for identifying leaks from microwave ovens or other microwave sources.

Whilst in the example shown in Figure 2, an external capacitor 5 is used to shunt the rectifying circuit 2, it is possible to use any form of external reactance to shunt the rectifying circuit 2 to achieve the voltage magnification effect.

Alternatively, the external capacitor 5 shown in Figure 2 can be removed and the Schottky diode junction capacitance can be utilised to achieve voltage magnification.

Thus, the detector provides advance warning when the RF radiation level exceeds a predetermined limit to prevent excessive radiation exposure. As can be appreciated from Figure 2, the design is simple, low cost and does not require a battery or external power source since it makes use of any RF radiation as its power sources.

The sensitivity of the detector is significantly enhanced by the voltage magnification in the rectifying circuit 2. The voltage magnification phenomenon is only observed when an external reactance or combination of external reactance is shunted across Schottky diodes which are partially-forward biased. Hence, the external reactance will primarily magnify the AC voltage produced by the antenna and the Schottky diode will rectify the magnified AC voltage to a usable DC voltage.

In the example shown in Figure 2, a linearly polarised antenna 1 is used. The amount of RF radiation received by such an antenna is sensitive to the orientation of the antenna 1. However, it is also possible to use other forms of polarised antenna such as circularly or elliptically polarised antennae. Such further forms of polarised antenna are not sensitive to the orientation of the antenna so the antenna 1 can be oriented toward the RF radiation source as required and the detector will still function.

Whilst the above described example uses a light emitting diode 9 as the indicator 3, it is also possible to use a voltmeter or ammeter connected across the rectifying circuit 2 so as to quantify the level of radiation being detected. The voltmeter or ammeter simply would need to be calibrated to display the appropriate power density level of RF radiation detected.

The example shown in Figure 2 can detect power densities as low as 0.01 mW/cm^2 but lower densities such as $1 \text{ } \mu\text{W/cm}^2$ can be detected depending upon the operating frequency and antenna gain. In any event, detectors embodying the present invention easily meet the leakage standard of 1 mW/cm^2 at a distance of 5 cms from a microwave source as set by the US Food and Drug Administration requirement for microwave oven manufacturers. Further, detectors embodying the present invention also meet the IEEE Standard which requires detection at 10 mW/cm^2 and 2 mW/cm^2 in an uncontrolled environment at 2.45 GHz.

It should be noted, referring to Figure 2, that the minimum voltage and current requirements of the indicator will determine how far the Schottky diodes in the rectifying circuit need to be biased thereby determining the parameters of the diodes.

The example of the detector shown in Figure 2 operates at 2.45 GHz. The rectangular patch antenna resonates at 2.45 GHz. It should be appreciated that this detector concept is also applicable throughout the microwave frequency range.

The matching circuit could be in the form of a single/double/multi open/short stub. It is, however, possible to manufacture the external reactance from a discrete component or from a form of transmission line.

**CLAIMS:**

1. An RF radiation detector comprising: an antenna for receiving RF radiation and producing an RF voltage; voltage magnification means to magnify the RF voltage; and a rectifying circuit to convert the magnified RF voltage received at the antenna to a DC voltage indicative of the level of radiation.
2. A detector according to Claim 1, wherein indicator means are provided to indicate the presence of RF radiation.
3. A detector according to Claim 2, wherein the indicator means provides an indication of the level of RF radiation.
4. A detector according to Claim 2 or 3, wherein the indicator means provides a signal indicative of a predetermined threshold level of RF radiation being exceeded.
5. A detector according to Claim 4, wherein threshold means are provided to set the threshold level.
6. A detector according to Claim 5, wherein the threshold means comprises a variable resistor connected in series or parallel with the indicator means.
7. A detector according to any one of Claims 2 to 6, wherein the indicator means is a light emitting device.
8. A detector according to Claim 3, wherein the indicator means quantifies the level of RF radiation.

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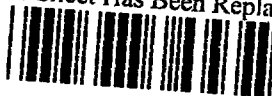


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9. A detector according to Claim 8, wherein the indicator means comprises an ammeter calibrated to quantify the level of RF radiation.
10. A detector according to any preceding claim, wherein the rectifying circuit comprises a pair of zero bias Schottky diodes.
11. A detector according to Claim 10, wherein the voltage magnification means comprises a reactance or combination of reactances, external of the rectifying circuit, to shunt the Schottky diode.
12. A detector according to Claim 10, wherein the reactance is primarily a capacitance.
13. A detector according to Claim 10, wherein the voltage magnification means comprises a junction capacitance in one of the Schottky diodes.
14. A detector according to any preceding claim, wherein a matching circuit is provided between the antenna and the rectifying circuit to match the two.
15. A detector according to any preceding claim, wherein the antenna is a linearly polarised antenna.
16. A detector according to any one of Claims 1 to 14, wherein the antenna is an elliptically polarised antenna.
17. A detector according to any one of Claims 1 to 14, wherein the antenna is a circularly polarised antenna.

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18. A detector substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

19. Any novel feature or combination of features disclosed herein.

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