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A Personnel Radio-Frequency
Radiation Monitor

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**A Personnel Radio-Frequency
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by

Frederic L. Fey, Jr.

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A PERSONNEL RADIO-FREQUENCY RADIATION MONITOR

by

Frederic L. Fey, Jr.

ABSTRACT

A personnel radio-frequency (rf) radiation monitor has been developed which indicates exposure to significant rf radiation by audible "chirp." The chirp rate is proportional to the power flux level down to an adjustable threshold which may be set as low as 0.1 mW/cm^2 . When this monitor is worn by a person, the threshold could be set at 10 mW/cm^2 to conform with the working level suggested by the American Standards Association.

The rf monitor circuit is composed of inexpensive and readily available components contained in a case the size of a cigarette package, yet it is stable and reliable. At a low chirp rate, it can operate continuously for 1 month on a small 4.2-volt mercury battery. This monitor would be valuable in guarding against overexposure and injury of personnel working in facilities where there are high power sources of rf energy, such as radio transmitters, particle accelerators, and radar installations.

Introduction

Personnel ionizing radiation detectors (pocket chirpers) have become very popular. Therefore, it was thought desirable to design a similar pocket chirper to detect significant levels of radio-frequency radiation. Several rf power density measuring instruments, valuable for measuring rf fields once they have been detected, are

commercially available. These instruments make use of the heating effect of rf radiation on a thermistor which causes an unbalance in a Wheatstone bridge circuit. The magnitude of this unbalance is read on a meter in units of mW/cm^2 . Because of the necessity of keeping the bridge balanced under zero power density conditions

and the need for visual monitoring of the meter, these instruments are not suited for the detection of unsuspected rf radiation.

General Description

An rf detector has been developed which can be worn on the person, and which indicates the existence of an rf field with an audible "chirp." The rf detector circuit, along with the audio oscillator and amplifier, is housed in a plastic case about the size of a package of cigarettes. The sensitivity of the device, that is the power density at which it begins to chirp, can be varied from above 10 mW/cm² to at least as low as 0.1 mW/cm². The American Standards Association presently suggests a working level of 10 mW/cm².⁽¹⁾ Since rf radiation causes injury by heating tissue, the energy density can not be averaged over long periods as is done with ionizing radiation exposure. The American Standards Association has recommended that energy density be averaged over no longer than 0.1 hour.⁽¹⁾ This restriction makes it very important that personnel not be allowed to receive exposure in excess of 10 mW/cm² even for short periods. For this reason, at the Los Alamos Scientific Laboratory we are trying to maintain occupied areas at a power density level below 1 mW/cm².

The device has also been found useful as a hand-held detector in finding sources of leaks such as around wave guides and cooling lines. The rf detecting circuit is such that the chirp rate remains proportional to power density above the threshold setting. Owing to the use of a tuned tank circuit, the device is somewhat frequency dependent. However, at Los Alamos we are using a single circuit for detection of both 200- and 800-MHz radiation.

Circuit Description

A schematic diagram and parts list is shown in the figure. Potentiometer P is the sensitivity adjustment; it sets the bias voltage on unijunction transistor Q1. As long as the bias voltage on Q1 is below a certain point, V_p , Q1 will not fire. When the tank circuit composed of L and C1 is subjected to an rf field, an oscillating current is set up which is rectified by diode D1. This dc current charges C2 until the emitter of Q1 reaches V_p . (C2 also has an integrating effect allowing use of the instrument for measuring pulsed rf fields.) At this point the transistor fires, discharging C2 and causing a negative pulse to be transmitted to the base of Q2.

Capacitor C1 can be varied to set the desired resonant frequency of the tank circuit. Diode D2 prevents the Q2 side of C3 from getting above the supply voltage and cutting Q2 off under high chirp-rate conditions. The negative pulse at Q2 causes it to turn on, charging C4 which turns on Q3. C4 discharges through R2 which determines the duration of the chirp. When Q3 turns on, C5 alternately charges through R3 and discharges through Q4. The value of R3 determines the audio frequency and is selected to provide the loudest chirp. This oscillating voltage is amplified by Q5, and T transfers the energy to the ceramic transducer which produces the audible chirp. Diode D3 serves the same purpose as did D2: it keeps Q5 from cutting itself off.

Prototype Experience

A few units have been in use for 6 months, mainly as hand-held survey instruments. These units have no on-off switch; however, current drain at idle is only 1.2 mA from the 4.2-volt mercury battery. The batteries have a 1,000-mAh life, which

Fig. 1. Personnel rf radiation monitor circuit.

B 4.2 V mercury	Q1 2N1671B	R1 1.2 kΩ	C1 5.5-18 pF
P 100 kΩ pot	Q2 2N3906	R2 15.0 kΩ	C2 47.0 μF
L 0.1 μh coil	Q3 2N3906	R3 4.7 kΩ*	C3 1.0 μF
T Lafayette 99-6126	Q4 2N1671B	R4 30.0 kΩ	C4 47.0 μF
D1 1N3731	Q5 2N1307	R5 1.2 kΩ	C5 0.1 μF
D2 1N143	D3 1N143	R6 100.0 Ω	C6 1.0 μF

*May have to be hand-picked owing to differences in characteristics of C5 and Q3.

allows them to be used for over a month.

Calibrating the device is done most effectively in the following manner. Set up an rf field using a transmitter capable of putting out a power density of at least 10 mW/cm². Using a field strength meter, find a point which reads the "working level" (1 mW/cm² at Los Alamos) and set the rf chirper so that it begins to chirp when it is brought to this point. Since the circuit is more sensitive in free space than when it is near an absorbing medium, it should be calibrated so that it will begin to chirp at the desired point while being worn by a person or attached to a similar absorbing medium.

Operating experience gained so far indicates that this monitor is stable and reliable in normal use.

ACKNOWLEDGMENTS

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REFERENCE

1. Proposed Standard, Electromagnetic Radiation Safety Level and/or Tolerances with Respect to Personnel, American Standards Association Committee C-95, 20 May 1964.