DESIGN AND CONSTRUCTION OF A BROAD-BAND ELECTRIC FIELD PROBE

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ABSTRACT

The design of a broad-band electric field probe based on a resistive film diode antenna on RT/Duroid substrate to measure the electric RF/MW fields as constructed at the National Radiation Protection Department (NRPD) of the Atomic Energy Organization of Iran (AEOI) are described in this paper. A square law diode detector with a matching circuit and also low pass filter have been used to produce a dc current proportional to the square RF voltage across the resistive antenna gap. A double-strip coplaner waveguide has also been designed to transfer this dc current to an amplifier with an output signal showing the electric field intensity in one direction. By using three mutually orthogonal resistive antennas, an isotropic electric field probe was made. All parts of this probe have been completely modeled and solved by the MATLAB computer program to determine the optimum values of the elements of the probe. The frequency response of the probe has also been theoretically found to be flat in the range 0.8 to 3 GHz. It was found to be quite satisfactory compared with those of similar probes commercially available. The probe is being used routinely in practice.

INTRODUCTION

Due to widespread applications of radiofrequency and microwave (RF/MW) sources in different disciplines, measurements of exposures from such fields are necessary for protection of workers and public. This requirement in Iran has been enhanced by the enforcement of regulations of the Radiation Protection Act of Iran (1). During the past two decades, significant advances have been made in instrumentation and techniques for measuring complex RF/MW fields applying resistive thin film screens (2) and resistive dipole antennas (3). These techniques have been investigated in this study both theoretically and experimentally for design and construction of a wide-band isotropic electric field probe using a three mutually orthogonal resistive dipole-diode. The design characteristics and performance of the probe as constructed at the National Radiation Protection Department (NRPD) are presented and discussed in this paper.

DESIGN CHARACTERISTICS AND EXPERIMENTS

By using a thin film technology, a resistive dipole antenna on an RT/Duroid substrate has been constructed with a design to have a wide-band antenna with a zero current at the end point and a maximum current at the center. A hyperbolic sinusoidal current distribution on the antenna was used to calculate the effective electrical length of the antenna and the open circuit RF voltage in the antenna terminal. A chip diode detector (which has an exponential characteristics) on the gap of the antenna was used. Whenever it operates in it's square law region, the dc component of the output current will be proportional to the applied squared voltage to the diode (4). Both the diode and the antenna impedance have dependency on the frequency so that the variation in frequency can affect them by a loading effect. Therefore, a matching circuit was used to cancel the loading effect (3). By this method, a relatively constant dc output for a constant amplitude of RF/MW exposure in different frequencies was obtained. To eliminate the ac component in the output of the diode and also to isolate the antenna and matching circuit from the other parts, a RC low pass filter was used. To transmit the

detected signal to the preamplifier, a resistive thin film symmetrical double-strip coplaner waveguide was used. This transmission line operated as a low pass filter and it provided an additional ac compensation (5). The dc output signal of the transmission line was amplified for monitoring of a high impedance meter. Figure 1 shows the circuit of one dipole-diode combination as designed and constructed in this work.

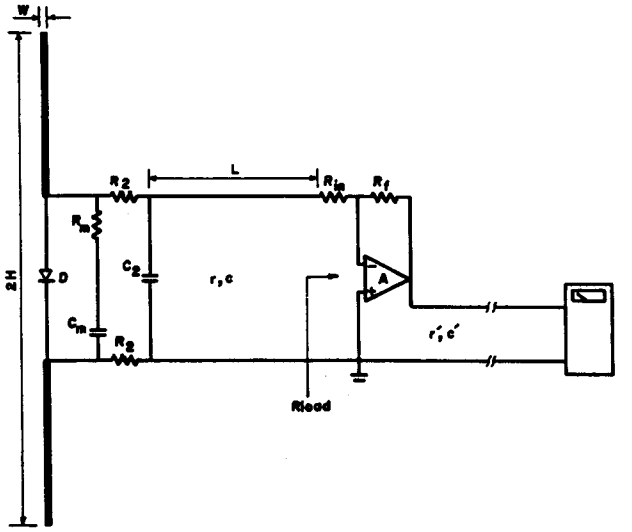
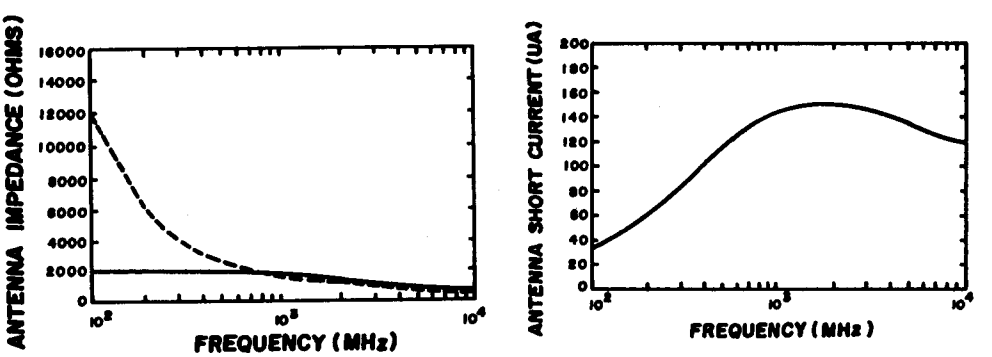


Figure 1. The circuit model of one directional dipole-diode combination RF/MW detector.

The electric field probe has been constructed based on a three orthogonal dipole-diode combination. Each dipole-diode is like the model shown in Fig. 1. A computer program was written using MATLAB to determine the optimum values of the elements of the probe such as antenna half length (H), dipole width (W), transmission line characteristics, etc. The output of the program for half length of the dipole was found to be 2 cm. The width and resistance of the dipole are parameters which limit the lower cut off frequency (2). A narrower width increases the lower cut off frequency but it makes the analysis easier. However, there is a trade off between the width of the dipole and the frequency of interest which was determined to be from 1 to 3 GHz. By running the program, the width of the dipole and antenna resistance were found to be respectively 0.1 cm and 3 kΩ per leg. Figure 2 shows the real and imaginary parts of the antenna impedance and it's short current versus the frequency.



(a) (b)

Fig. 2. a) The real and imaginary parts of the resistive dipole impedance; b) the antenna short current.

By modeling the diode and the other parts of the probe and by running the program at different frequencies of interest, the frequency response of the probe was determined, as shown in Fig. 3. It can be concluded that the probe has a response flat in the frequency range of 0.8 to 3 GHz which matches with our preset frequency range of interest. The probe was constructed based on the output results of the program as shown in Fig. 4. By comparative calibration of the probe, the RF/MW exposures in the environments of such fields and in the working areas were measured. The response of the probe was compared with those of other available field probes and it's response was acceptable.

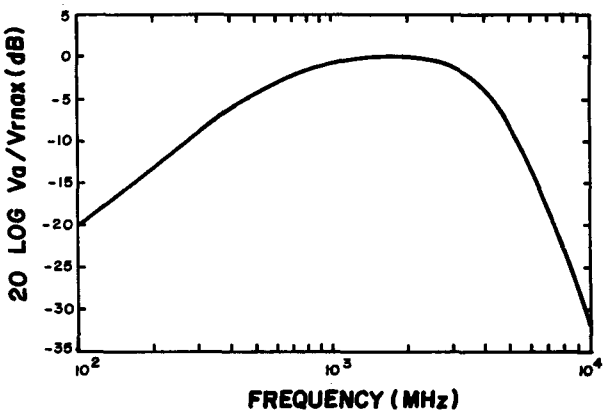


Figure.3 The frequency response of the probe.

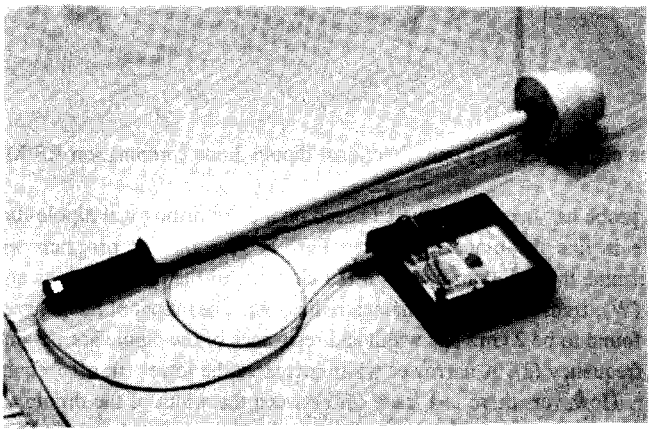


Figure 4. The electric field probe as constructed in this study.

CONCLUSION

In this study, a wide-band RF/MW measuring probe was designed and constructed which showed satisfactory performance characteristics and it has been applied in practice. Studies are underway to further upgrade the system.

REFERENCES

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