International Microwave Power Institute

19th ANNUAL MEETING

SEPTEMBER 17th, 18th & 19th 1984

MINNEAPOLIS, MN.

PROGRAM ABSTRACTS & SUMMARIES

THREE DIMENSIONAL TEMPERATURE GRADIENTS BY THE INVERSE BLACK BODY RADIATION METHOD

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ABSTRACT

The theory of thermal radiation is employed to derive the passive signature of a three dimensional lossy dielectric object with a temperature gradient. A numerical procedure is then applied to retrieve the gradient from known thermal power emission at the surface of the body.

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SUMMARY

The purpose of this paper is to explore radiometric techniques for the retrieval of physical parameters of an object. Temperature gradients, in three dimensions, are imposed on simple theoretical three dimensional objects as the parameters to be retrieved. All other physical parameters are held constant or at least are known throughout the object. The objects are made up of simple non-scattering dielectric material where it is assumed for the calculations in this paper that the attenuation constant of the dielectric is that of plexiglass at microwave frequencies.

The theory of thermal radiation as given in Planck's Law is explained first and then applied to the problem at hand. Specifically, if the power emitted from several points on the surface of an object is known then it is possible to determine the approximate value of an unknown parameter at as many locations throughout the body as the number of power samples taken from the surface. In other words, the object is scanned and N emitted power measurements are taken at several positions on the surface, and from these N measurements the unknown desired parameter (in this case temperature) at N different points inside the body can be calculated.

This method is developed in three separate parts. First the power emitted from the surface of a small cube of size t at constant temperature is obtained for different cube sizes and attenuation constants of the dielectric material which makes up the cube. This calculated power density is then assumed to originate totally from an infinitesimal cube at the geometrical centre of the small cube. Then the "intensity" of this infinitesimal cube in the centre of the small cube is calculated so that the power density received at the surface due to the centre cube alone and with the rest of the cubes suppressed is the same as that of the total cube radiating. Thus the total cube can be replaced by this infinitesimal isotropic radiator or point source.

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Next a numerical model of an object with three dimensional temperature gradients is introduced this numerical model the emitted powers from N points on the surface of the object are calculated.

In the third part the object with the temperature gradients is numerically divided into N small cubes of dimension t and it is assumed that the emitted thermal radiation from these cubes originate from an isotropic radiator as calculated in part one. Then the N theoretical equations involving the N emitted powers at each of the N points at the surface of the object due to all N assumed isotropic radiators are set up. Thus the final step involves solving the N equations in N unknowns to find the temperature at the N points throughout the body. Numerical results are presented which illustrate that accurate temperature gradients can be retrieved from the known thermal power emission at the surface of the body.

The authors wish to acknowledge the financial support of The Centre for Transportation Studies of the University of Manitoba and The Natural Sciences and Engineering Council of Canada.

REFERENCES:

1. M.A.K. Hamid, "Radiometric Signatures of Complex Bodies", Proc. AGARD E.M. Wave Propagation Panel, CP-144, The Hague, Netherlands, March 1974, pp.21.1-21.27 (Invited)

2. M.A.K. Hamid and J.D. Hunter, "Examination of Surface Coatings by Microwave Radiometry", Proc. NATO Advanced Study Institute on the Science and Technology of Surface Coating, Imperial College, University of London, England, April 1971.
(Reprinted in "Science and Technology of Surface Coating", Academic Press, London and New York, pp.423-431).

3. M.A.K. Hamid, "Retrieval of Target Parameters by Microwave Radiometry", Int. J. Electronics, Vol. 36, No.4, 1974, pp.521-526.

4. T.R. Hartz, "A Radiometer Method for Determining the Thickness of Sea Ice", Communications Research Centre, CRC Report No. 1217, Ottawa, May 1971.

5. M. Tiuri, A. Laaperi and K. Jokela, "Passsive Radiowave Sensing of the Thickness and Other Characteristics of Sea Ice", Helsinki University of Technology, 1975.

6. E.M. Sparrow and R.D. Cess, "Radiation Heat Transfer", California, Brooks-Cole, 1966.

7. F.T. Ulaby, "Microwave Remote Sensing: Active and Passive", Vols. 1, 11, and 111, Addison Wesley, 1981.