MICROWAVE RADIOMETRY AS A WAY TO MEASURE AND CONTROL TEMPERATURES IN MEDICAL APPLICATIONS.

C. RICARD[(1)], L.DUBOIS[(1)], L.BEGHIN[(2)], P.-Y. CRESSON[(1)], J. PRIBETICH[(1)].

[(1)] I.E.M.N. - U.M.R. C.N.R.S. N° 8520 - Département Hyperfréquences & Semiconducteurs
Université des Sciences & Technologies de LILLE1 , Avenue Poincaré - B.P. 69
59652 VILLENEUVE D'ASCQ CEDEX - France
Phone : 33 (0) 320 19 79 54 ; Fax : 33 (0) 320 19 78 98 ; e-mail : Joseph.Pribetich@IEMN.univ-lille1.fr

[(2)] Centre d'Investigation Clinique du Centre Hospitalier Régional et Universitaire de Lille
Hôpital Cardiologique , Boulevard du Professeur Jules Leclercq - 59037 LILLE Cedex

I. INTRODUCTION.

The measurement of the corporal temperature gives an important information for a lot of clinical studies. It is very interesting in the scope of diagnosis and monitoring of many pathologies. For example, the circadian rhythm corresponding to a 24 hours cycle is closely connected to the variation of the human temperature. So a malfunctioning of the biological rhythm due to medical, environmental or social factors can be detected by the measurement of the human temperature.. This paper is concerning the realization of new miniature sensors allowing to measure the human central temperature with a non-invasive way by microwave radiometry.

II. MATERIAL AND METHODS

The techniques most currently used for temperature measurements among men are built on the use of thermometers, thermocouples, optical fibers or infrared sensors. Their drawbacks are to give a superficial or a punctual information and are sometime traumatizing. Microwave radiometry can bring a precious assistance in the research in chronobiology. The principle is the following : any dissipative body emits spontaneous electromagnetic radiations of thermal origin. In the microwave frequency range, this thermal noise power is directly proportional to the temperature. Thus, the temperature can be determined by use of a sensitive receiver called radiometer which uses an antenna or applicator as an electromagnetic power sensor. For this study, we make use of a "cold" sensor connected to a radiometer working around 3.2 GHz with a bandwidth of 500 MHz. It is realized from a copper film laid on a dielectric substrate of relative permittivity $\varepsilon_r = 10.2$ and of thickness 1.27 mm and inserted in a box in order to pick up only the radiating pattern arising from the body. The modeling of this applicator is based on the resolution of the Electrical Field Integral Equation expressed in the Spectral Domain Approach and solved by a moment's method, the GALERKIN method. It allows us to obtain in a short time the dimensions of the applicator for an optimum working, the frequency variations of the reflection coefficient $|S_{11}|$ and also the electric field distribution from which we can deduce the receiving pattern.

III. RESULTS AND DISCUSSION.

The first phase of the clinical study in collaboration with the Center of Clinical Investigation (CCI) of the CHRU/INSERM of Lille is to demonstrate the feasibility and the consistency of the measurement of human temperature by microwave radiometry. Although the results have proved the coherence of the measurements compared to classical techniques mentioned above, two important points must be mentioned : the transitional state due to the rise in temperature of the sensor which is directly in contact with the skin and the deficiency of the volume of tissues in depth contributing to the radiometric temperature. So, in order to compensate these drawbacks, it is necessary to work at a lower frequency (around 1,575 GHz). The new sensor has been realized on an epoxy substrate (permittivity $\varepsilon_r = 4{,}9$) of thickness 1.58 mm. The geometrical dimensions have been calculated in order to be used at a distance from the skin equal to 3 mm as to reduce thermal exchanges. We have chosen a technique of reduction of antennas proposed by par R. AZADEGAN. A campaign of measurements on phantoms equivalent to human tissues is now in progress. A second clinical study with the CCI which goal is to follow up the thermal cycles of internal organs (such as the liver) is in preparation.

IV. CONCLUSION.

We have studied a new generation of sensors for temperature measurement and control in medical applications. The experimental measurements performed on volunteers are very cheering in spite of the difficulty to achieve them and show the potentiality of this technique. Other fields (such as food industry) take a great interest in this method of non-invasive temperature control.