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Novel Interference Voltage Sensor Using an Electro-Optic Converter for Active Implantable Medical Devices EMI Assessment

Naoki TANAKA † Takashi HIKAGE † Toshio NOJIMA †
Takahiro IYAMA ‡ Junji HIAGASHIYAMA ‡ and Teruo ONISHI ‡

† Graduate School of Information Science and Technology, Hokkaido University
Kita14, Nishi9, Kita-ku, Sapporo, Hokkaido, 060-0814 Japan
‡ NTT DOCOMO, INC.
3-6 Hikarinooka, Yokosuka-shi, Kanagawa, 239-8536 Japan
E-mail: hikage@wtemc.ist.hokudai.ac.jp

Abstract An interference voltage sensor for active implantable medical devices (cardiac pacemakers / ICDs) EMI assessment is newly developed by applying direct modulated Electrical to Optical (EO) converter. The sensor can be connected an actual pacemaker lead and measured induced voltage without disturbing electromagnetic fields emitted from tested RF device because I/O signal of the sensor are made through optical fiber. As one example, measurement of interference voltage due to a cellular base station antenna is demonstrated.

Keyword Active Implantable Medical Device EMI, Interference voltage, Electro to Optic conversion

1. Introduction

Wireless devices such as mobile phones, RFIDs, and wireless power transfer systems are essential devices to realize the ubiquitous and universal network society. These devices emit electromagnetic fields (EMF) that could potentially cause electromagnetic interference (EMI) for other electromagnetic devices.

The EMI on active implantable medical devices (AIMDs) such as implantable-cardiac pacemakers and cardioverter defibrillators (ICDs) is one of the most important issues needing investigations [1-4]. This is because the number of AIMD users is increasing every year due to the aging of the population.

In this paper, we newly develop an interference voltage sensor for AIMD-EMI assessment by using direct modulated Electrical to Optical (EO) converter. Furthermore, measurements of interference voltage of a pacemaker due to a cellular base station antenna are demonstrated.

2. Development of Interference Voltage Sensor for AIMD-EMI Assessment

EMI impacts pacemakers/ICDs when the sensing circuit of the pacemakers receives a signal similar to “an electrocardiogram signal” or “noise,” and the signals’ strength is higher than the sensing threshold level of the pacemaker/ICD. The induced voltage on feed-through filter of the pacemaker/ICD sensing circuit by the received external signal is defined as “interference voltage”. If the interference voltage exceeds the pacemaker's/ICD’s sensing threshold level, it may malfunction. In order to assess the pacemaker/ICD EMI from RF/EMF emitters, human torso phantom has been used [4]. The torso phantom is comprised of a saline tank and electrodes. The saline tank is constructed from acrylic panels and is filled with a saline solution, with the density of 1.8 g/l NaCl concentration. Pacemaker is placed in the saline tank during the EMI assessment test in order to operate properly as is implanted in human body.

It is very difficult to obtain actual induced interference voltage on the internal circuit inside the pacemaker’s enclosure (CAN) by measurement. Here, we newly develop interference voltage sensor by installing small-sized EO converter [5] in the pacemaker CAN with a perfect waterproof structure. Figure 1 shows configuration of the developed interference voltage sensor. This sensor can be connected an actual pacemaker lead in uni-polar mode and can measure induced voltage without disturbing electromagnetic fields because I/O signal of the sensor are made through optical fiber. The input impedance of the sensor is 50 Ω, and the minimum sensitivity is approximately -80 dBm from 10 MHz to 6 GHz frequency range. Although the sensitivity is slightly deteriorated at the lowest and highest frequencies, actually, this sensor can be used in frequency range from 100 kHz to 6 GHz.

3. Measurement of interference voltage due to a cellular base-station antenna

In one example, we measured interference voltage due to a cellular base-station antenna emitting 2 GHz band RF wave using the developed sensor placed into the torso-phantom. Figures 2 and 3 show constructed measurement-setup and measured distance dependence of interference voltage, respectively. The interference voltages were measured when the base-station antenna operating at 2.1 GHz both in vertical and horizontal polarization. Measured results confirmed the developed sensor can obtain interference voltage precisely.

4. Conclusions

Novel interference voltage sensor for AIMD-EMI assessment was developed by applying direct modulated EO converter and constructed a measurement set-up. Measurements of interference voltage due to a cellular base station antenna were demonstrated. In the future, the developed set-up can be applied for other wireless systems.

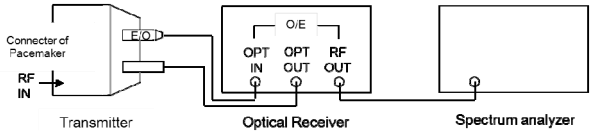

Fig. 1 Developed interference voltage sensor.

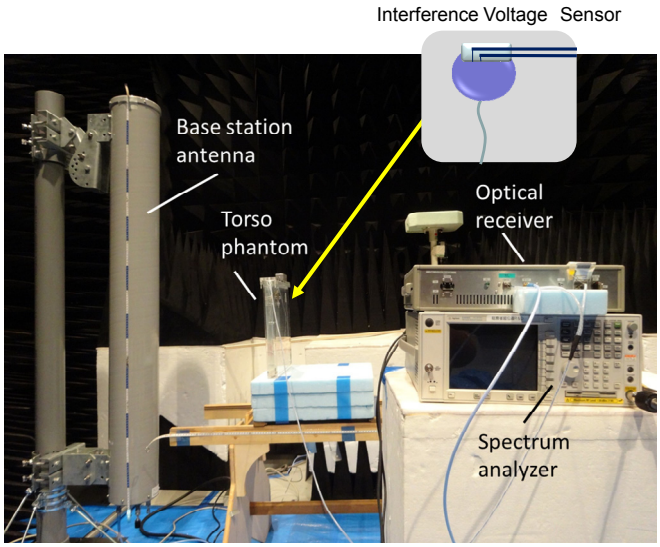

Fig. 2 Measurement set-up for interference voltage due to a cellular base-station

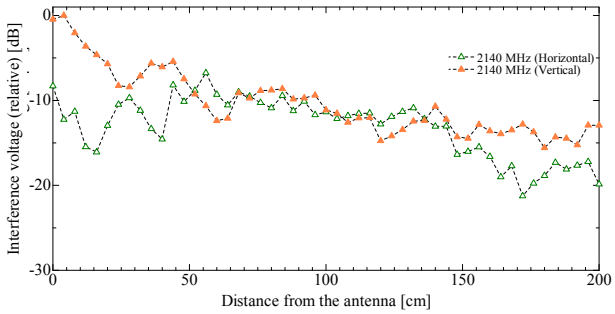

Fig. 3 Measured distance dependence of interference voltage due to a cellular base-station (2.1 GHz-band)

References

[1] W. Irnich, L. Batz, R. Muller and R. Tobisch, "Electromagnetic interference of pacemakers by mobile phones," J. Pacing and Clinical Electrophysiology, vol. 19, no. 10, pp.1431-1446, Oct. 1996.

[2] D. L. Hayes, P. J. Wang, D. W. Reynolds, M. Estes III, J. L. Griffith, R. A. Steffens, G. L. Carlo, G. K. Findlay and C. M. Johnson, "Interference with cardiac pacemakers by cellular telephones," New Engl. J. Med., vol. 336, no. 21, pp. 1473-1479, May 1997.

[3] T. Toyoshima, M. Tsumura, T. Nojima and Y. Tarusawa, "Electromagnetic interference of implantable cardiac pacemakers by portable telephones," Japanese J. Cardiac Pacing and Electro-physiology, vol. 12, no.5, pp. 488-497, 1996.

[4] "Guidelines on the use of radio communications equipment for implanted medical devices," Ministry of Internal Affairs and Communication of Japan, Aug. 2005.

[5] T. ONISHI, S. ISHIHARA, and J. HIGASHIYAMA," Electromagnetic Field Measurement Using the Directly Modulated Electrical to Optical Conversion," IEICE Tech. report, PEM2014-15, Feb. 2015.(In Japanese)