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The European Experience

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Abstract

This article presents an overview of past and current experiences with time division multiple assess–based (Global System for Mobil Communication) mobile telephones in Europe as seen by the European Hearing Instrument Manufacturers Association. Initial fear of widespread interference problems for hearing aid users in general owing to use of a new generation of mobile telephones seems unjustified. The background for the International Electrotechnical Commission 118-13 standard for measuring interference is described. No solution to complete elimination of interference problems resulting from direct contact between hearing aids and mobile telephones has yet been found. Several reports on the subjects are cited, and new work on measurement standards for near-field situations is mentioned.

Key Words: European Hearing Instruments Manufacturers Association, Global System for Mobile Communication, hearing aids, interference, mobile telephones

Abbreviations: BTE = behind the ear, DECT = digital European cordless telephony, EHIMA = European Hearing Instruments Manufacturers Association, EMC = electromagnetic compatibility, ETSI = European Telecommunication Standards Institute, EU = European Union, GSM = Global System for Mobile Communication, IEC = International Electrotechnical Commission, IRIL = input-related interference level, ITE = in the ear, TDMA = time division multiple access

The purpose of this article is to present an overview of the situation regarding compatibility problems between mobile telephones and hearing aids as it has developed in Europe in recent years. The European Hearing Instruments Manufacturers Association (EHIMA) has played a significant role in this development, and the viewpoints presented are those of EHIMA.

EHIMA

EHIMA is in several ways the European equivalent of the Hearing Industry Association in the United States, but with some important differences. The members of EHIMA are exclusively hearing aid manufacturers, and to become a member, you must document that your annual production is more than 25,000 hearing aids. The current members of EHIMA are A&M (United Kingdom), Bernaphon (Switzerland), Coselgi (Italy), GN Danavox (Denmark), Interton (Germany), Oticon (Denmark), Philips (Netherlands), Phonak (Switzerland), Resound-Viennatone (Austria), Siemens (Germany), Starkey (Germany), and Widex (Denmark). The EHIMA group represents the manufacturers of more than 2 million hearing aids a year and a business volume of more than $850 million, of which a fair share is exported to the United States.

The purpose of EHIMA is to be a forum for discussion of matters of mutual interest among manufacturers and to maintain the interests of the industry, particularly with the European Union (EU) authorities. The secretariat resides in Brussels, Belgium. The two annual General Assemblies are typically attended by the presidents of each member company. Technical matters that frequently appear on the agenda are handled by the Technical Committee. Each member company appoints a technically competent person, typically the research and development manager. The author has been a member of this committee since 1989 and has chaired it in two periods: from 1991 to 1993 and from 1996 to this day.

HISTORICAL OVERVIEW

Hearing aids and mobile telephones have coexisted peacefully for many years. Ana-

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log systems at 450 and 900 MHz have been in use for many years, and almost no problems have been recorded. Occasionally, incidents where demodulation of the carrier caused shifts in the working point of single-transistor stages were reported, but these incidents were few and often managed by some simple decoupling methods, so mobile telephones were not an issue at the EHIMA Technical Committee meetings. In October 1992, news on a new digital system for mobile telephony reached EHIMA from several sources simultaneously. The author was personally informed by friends in Danish Telecom, and EHIMA received a brief from the European Telecommunication Standards Institute (ETSI) explaining that the Global System for Mobile Communication (GSM) was coming and that it was known that it would cause serious interference in hearing aids and other equipment based on analog circuit technology. A report addressing the problems to be experienced with hearing aids in particular was also made available. EHIMA was, of course, alarmed and quickly sent a memo to the EU authorities pointing out how unacceptable it was to be involved at this very late stage when all was said and done from a legislative point of view and where the message received by EHIMA was "You better prepare yourselves for this new twist of fate; it will cause serious difficulties, and we can do little to help you. Our best advice is that you encapsulate the hearing aids in a complete metallic shield."

EHIMA was, of course, by no means adverse to the general concept of devising a pan-European system for mobile telephones. With the GSM, there was a unique opportunity to create a worldwide telephone system. Currently, many countries all over the globe are already connected, and we can all experience the benefits of this, but from a hearing aid professional's point of view, EHIMA was appalled by the way the whole thing came about. After having posted a series of indignant letters that were received with polite indifference, we concluded that it was time to start working to find out how bad it really was, how to measure it, and how to protect our hearing aids from this hostile attack—the proliferation of what someone appropriately termed "electrosmog." The worst-case scenario was that a large proportion of the estimated 5 million hearing aid users in Europe would be constantly bothered by the widespread use of GSM or other time division multiple access (TDMA)–based telephone systems.

The First Assessments

In the first months of 1993, the three Danish manufacturers were approached by the Danish Telecom laboratories that had set up a test facility for the testing of GSM mobile telephones. They offered to do a series of measurements on hearing aids to give a first-hand impression of the problems. The Technical-Audiological Laboratories (Odense, Denmark) were asked to assist in the measurement program to have staff with hearing aid expertise involved. The measurements were carried out in free field with a field strength of 10 V/m with GSM and digital European cordless telephony (DECT) modulation patterns on a total of 14 behind-the-ear (BTE) and in-the-ear (ITE) aids. The results confirmed the concerns. Most aids were seriously affected by the TDMA signals both on microphone and telecoil. The input related interference level (IRIL) term was suggested in this project (Otwidan/Telecom/TAL, 1993).

In the spring of 1993, EHIMA contracted with the Technical-Audiological Laboratories to do a more comprehensive project. The objectives were to (1) evaluate the annoyance of GSM interference on a range of typical hearing aids and propose a measure to quantify the interference and a level of acceptance, (2) develop a reference measurement set-up and recommend a low-cost set-up for the manufacturers, and (3) initiate standardization of these measurement techniques. The interference had previously been recorded on digital audiotape to speed up the measurement procedure so that a thorough analysis of the interference signals could be done offline. To evaluate the annoyance of GSM interference, typical interference was played back to a group of normal-hearing persons in the presence of different background noises. Their task was to judge the annoyance of the interference presented at different levels. Based on these evaluations, a value of 55 dB SPL was proposed as the maximum tolerable input referred interference level (IRIL). This level was somewhere between slightly annoying and annoying. This value was subsequently proposed for the International Electrotechnical Commission 60118-13 standard (IEC, 1997). Later work at the Acoustical Laboratories at the Technical University of Copenhagen confirmed these findings on hard-of-hearing subjects. It was also concluded that the interference from DECT modulation was slightly more annoying than GSM, probably owing to the much smaller duty cycle.

Every EHIMA member company submitted aids for testing and got a specific measurement report on their own aid, whereas data on all of the other aids were presented anonymously. Other important findings were that the interference spectrum was almost the same in all aids when the output spectra were normalized with the gain curve of the aid, suggesting that most of the interference originated from the microphone or input stages of the electronic circuits. The dominant part of the interference was below 1000 Hz and decreased with increasing frequency. It also showed that various orientations were needed to find the worst-case conditions for interference. The relationship between interference and field strength was found to have approximately a 2:1 ratio. With an increase of 10 dB in field strength, a 20-dB increase in interference appeared. These findings were available as an internal EHIMA report in October 1993. After some editorial changes and further measurements, the report was made publicly available from the EHIMA secretariat in June 1995 (EHIMA, 1995). So far, measurements had been carried out in free field conditions at the Telecom laboratories. Such an arrangement is clearly not practical for a hearing aid company. Two recommendations for low-cost set-ups were proposed. One was to use a simple strip-line of suitable dimensions to create a well-defined field. To avoid disturbing the neighbors, this should be done in a radio-shielded room. Another option is to use gigahertz transverse electromagnetic cells that do not disturb but are quite expensive if they must cover all frequencies up to 2 GHz.

Electromagnetic Compatibility Directive and IEC Standardization

It was also requested from EHIMA that a standardization initiative be taken. This was quite vital in view of the electromagnetic compatibility (EMC) directive issued by the EU authorities to be effective from January 1, 1996. In this directive, it was specified that no product should emit or be susceptible to desired emissions from other equipment and that product-specific standards were to be made for all relevant products. Products that did not comply with the standards would not be sellable after the end of 1995. At this stage, people with a general EMC background got involved, and the directive was found to be more in line with other standards to use a 1-kHz sine-wave modulation instead of the actual GSM. After some mathematical manipulation, it was found that 80 percent sinusoidal amplitude modulation gave an equivalent interference if the peak field strength was the same, which means that the amplitude of the unmodulated carrier was reduced from 10 to 5.4 V/m. Ten V/m is equivalent to a 2-watt 900-MHz transmitter at a distance of 1 meter. On the basis of real-life experience, it was judged that very few would carry on a private conversation on a mobile telephone that close to other people, so it was concluded that a reduction of 3 V/m at 900 MHz for the unmodulated carrier would be an appropriate field strength for testing for interference from other people's use of mobile telephones. This corresponds to about 2 meters distance. The maximum power of the services planned for the 1800-MHz range was only 1 watt, but since the hearing aids seemed more susceptible to interference in this range, the test field strength was set to 2 V/m. Another good question raised in the standardization work was the frequencies at which measurements should be taken. The two frequency ranges defined for TDMA–type services were around 900 and 1800 MHz. It was strongly advocated by the hearing aid industry that testing should be restricted to these frequencies as long as no other services were in view. With the threat of having to immunize hearing aids for the very high field strengths experienced when using a GSM telephone, life was difficult enough as it was. Many measures that protect the aid at one frequency range are without effect at the double frequency and vice versa.

The IEC 60118-13 currently states that measurements have to be carried out in the range of 800 to 960 MHz and 1400 to 2000 MHz. Practical experience seems to confirm the limits defined in the IEC 60118-13 (IEC, 1997). In 1994, a study of the situation in Denmark was undertaken owing to massive pressure from the hard-of-hearing associations. A project group with participation from all parties to the problem was established: government, hearing aid manufacturers, telephone manufacturers, operators, and hearing aid users. Denmark has excellent market statistics, so it was possible to identify the 50 types of hearing aids that had been dispensed over the preceding 3 years. Both the bystander and the near-field user situations were discussed, and the outcome was a classification scheme with different levels of immunity. The deal was that the hearing aid industry would publish data on their products after a certain period to allow them to optimize and measure their products. Two samples of each aid

were tested, and the results showed that all ITE aids were below the 55 dB IRIL limit, and the majority of the BTE aids as well, with a 10 V/m real GSM modulation (EHIMA, 1995).

The question of interest now is have we had any complaints about bystander interference? The answer is no. To the author's knowledge very few complaints have been received from people being bothered by use of GSM telephones in their vicinity. The reason could be low activity, but not in Denmark. Currently, we have 1.1 million active GSM telephones for a population of 5 million people in a relatively densely populated country that is fully covered. The telephones are being used several hours every month. This is proof of the appropriateness of the 55-dB limit for interference from other peoples' use of GSM telephones.

The burning question not yet answered was what about the use of a GSM telephone by a hearing aid user; would that be possible? The difficult part of this problem was to give a realistic estimate of the field strength at the hearing aid. Field strength ranging from 30 to 150 V/m was claimed. Since it is in the near field and very dependent on the relative position of both telephone and the hearing aid, no conclusion on this matter was reached at the time when the standard was drafted. This is not to say that it is not an important question, but since little solid information was available, no agreement was reached at the time.

FUTURE WORK

This is where we stand today: most of the objectives defined by EHIMA in 1994 have been met. A quantity representing the interference has been defined: the IRIL. An appropriate acceptance level for annoyance to hearing users not using telephones themselves has been established. Measurement methods both for reference and practical work have been defined, and an IEC standard is almost ready to be issued. All results and considerations so far reported and a few more can be found in the EHIMA report (EHIMA, 1995). It has been forwarded to many whom we thought would be interested in reading it, and it can be requested from the EHIMA secretariat.

The question still remaining is that of how to define appropriate immunity for hearing aids when used directly with a GSM telephone. Measurement results from the German Physikalische Technische Bundesanstalt organization (Richter and Schädler, 1996) are of interest in this context. They have measured, on a number of recently developed hearing aids, to find the field strength where an interference corresponding to an IRIL value of 55 dB occurs. In this way, the difficult question of defining the field strength at the hearing aid is again avoided. The results of measurements at 900 MHz with microphone and telecoil input show that some aids are better on microphone and some are better on telecoil. No consistent pattern appears. At 1900 MHz, the same result is seen with generally lower field strengths. A comparison of the performance at 900 and 1900 MHz shows again that good performance at one frequency is followed by poor performance in another. Only a few aids can be considered safe to use directly with a mobile telephone and only at one frequency. The sad fact is, however, that soon we will have mobile telephones that can work at both ranges depending on the availability of a free time slot. The field strengths experienced with the antennas close to the hearing aid are not well established, but practical experience shows that many of the hearing aids made today, particularly BTE devices, are susceptible to interference in such a degree that it is annoying. The measurements were carried out as swept measurements, which is only possible because of the sine-wave modulation measurement technique. These measurements show that the immunity of current hearing aids varies dramatically with frequency, which is why EHIMA is against setting immunity limits for any frequency range where no TDMA–based services are offered. This sad state of affairs is not a result of a lack of effort on the manufacturer's side; it is not easy to protect a device designed to pick up electrical signals in the μV range from a device emitting 2 watts of high-frequency energy 5 cm from it.

EHIMA's conclusion is that, without the cooperation of the telephone manufacturers, we will not be able to solve this problem completely. Our suggestion is to try to move the antenna away from the part that connects to the ear. Just a mere 10 to 15 cm would help tremendously. Our recent thinking is that we would like to publish data on our products stating what field strength they can handle with a modest level of interference as a result. If then the telephone manufacturers could publish data on the field strength at a certain reference point, a basis for pairing hearing aids and telephones would be established to the benefit of all. A review of the recent draft American National Standards Institute standard on this complex problem (ANSI, 1996) shows that

this line of thinking was adopted in the draft. We have currently not been able to develop a good method for measuring the near field from mobile telephones, so the EHIMA Technical Committee looks forward to working with the ANSI group on this. It is the author's hope that it will be possible to come to a solution whereby hearing aid manufacturers will not have to acquire more expensive equipment. EHIMA will continue to have regular meetings with ETSI, the operators, and mobile telephone manufacturers to see if we can progress further down this path.

REFERENCES

American National Standards Institute. (1996). *American National Standard for Methods of Measurement of Compatibility between Communication Devices and Hearing Aids.* C63.19.199X Draft. New York: IEEE.

European Hearing Instruments Manufacturers Association. (1995). *Hearing Aids and GSM Mobile Telephones: Interference Problems, Methods of Measurement and Levels of Immunity. GSM Project Final Report.* Wemmel, Belgium: EHIMA.

International Electrotechnical Commission. (1997). *IEC 60118-13 Hearing Aids, Part 13: Electromagnetic compatibility (EMC) Product Standard for Hearing Aids.* Geneva: IEC.

Otwidan/Telecom/Teknisk Audiologisk Laboratorium. (1993). *Hearing Aids / GSM.* Version 2.50. Copenhagen: Otwidan.

Richter U, Schädler S. (1996). *EMV-Messungen an Hörgeräten (Trägerfrequnzbereich 80 MHz bis 2000 MHz), PTB-MA-51.* Bremerhaven, Germany: Wirtschaftverlag NW.