Relevant Recent Papers in support of ANSI C63.19

This document provides a listing of six peer-reviewed papers published in the last five years that are all related and relevant to the work of ANSI C63.19. These papers have been published in two journals, the IEEE EMC Magazine and the Journal of the American Academy of Audiology. The following individuals collaborated on one or more of these papers:

Brian Beard, PhD, Deputy Director, FDA/CDRH/OSEL/Division of Biomedical Physics
Scott Isabelle, Ph.D., Mobile Systems Architect, Intelligent Audio Knowles
Stephen Julstrom, Julstrom Consulting and Development
Linda Kozma-Spytek, Senior Research Audiologist, Technology Access Program, Gallaudet University

IEEE EMC Magazine

Three related articles have now appeared in the IEEE EMC Magazine resulting from a multi-year study project under the Rehabilitation Engineering Research Center on Hearing Enhancement.

The first article presented an improved method for GTEM testing of hearing aid immunity and has since received generally confirming study by EHIMA (European Hearing Instruments Manufacturers Association).

1) **Julstrom**, S.D.; **Kozma-Spytek**, L.K.; **Beard**, B.B., "Radio frequency immunity testing of hearing aids," in *Electromagnetic Compatibility Magazine, IEEE* , vol.2, no.2, pp.69-81, Second Quarter 2013

Abstract: For many Equipment Under Test (EUT), such as the hearing aids examined in this study, the desired RF immunity measurement result is that which would be measured in the most sensitive EUT orientation relative to an applied RF field. This is generally approximated from measurements at a number of predetermined orientations within a GTEM cell. This paper presents new 6 and 12-orientation “maximal sum” methods of small EUT immunity measurement, which may be considered extensions to present sorted three-input vector summation techniques. Experimental results for the new methods approached the established reference goal more consistently than did other approaches examined employing a comparable number of contributing measurements.

URL:
http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6550935&action=search&sortType=&rowsPerPage=&searchField=Search_All&matchBoolean=true&queryText=(%22Document%20Title%22:hearing)&refinements=4294967269&refinements=4291944246&ranges=2013_2013_Year

---

The second and third IEEE EMC Magazine papers are a two-part series summarizing the main results of the multi-year study, correlating hearing aid immunity and cellphone emissions measurements to corresponding combined in-use coupled interference measurements.

2) **Beard**, B.B.; **Julstrom**, S.D.; **Kozma-Spytek**, L.K., "RF interference in hearing aids from cellphones part 1: Near-field cellphone emissions measurements and the effects of hands," in *Electromagnetic Compatibility Magazine, IEEE* , vol.4, no.3, pp.59-66, 3rd Quarter 2015

Abstract: Cellular telephones (cellphones) are currently categorized for hearing aid compatibility

based on a calculated value (metric) obtained from the measurement of near-field, radio-frequency emissions according to a procedure described in ANSI Standard C63.19 “Measurement of Compatibility between Wireless Communications Devices and Hearing Aids”. There has been a lack of documentation, however, that relates this metric to a cellphone's potential for interference in actual use, that is, when it is held at the ear in a normal-use position by a hearing aid wearer. In Part 1 of this two-part series, we compare the ANSI C63.19 metric to simpler metrics, still based on the near-field test procedure of the standard, and to near-field measurements made when the cellphones are hand-held. The results justify employing a simpler no-hand metric than the exclusion area procedure presently specified by the standard, but not the addition of a test hand to the procedure. The further effect of the head and interaction with the hearing aid is examined in Part 2 of the series.

URL:
http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7336757&searchWithin=%22Authors%22:.QT.Stephen%20D.%20Julstrom.QT.&newsearch=true

3) **Julstrom**, S.D.; **Kozma-Spytek**, L.K., **Beard**, B.B., "RF interference in hearing aids from cellphones part 2: Comparing in-use RF coupling to predictions," in *Electromagnetic Compatibility Magazine, IEEE* , vol.4, no.4, pp.66-77, 4th Quarter 2015

Abstract – Cellphones and hearing aids are presently tested for their near-field RF emissions and RF immunity, respectively, to predict their mutual compatibility when used together. In the concluding part of this two-part series, we examine the relationship between these independent device measurements and the resultant in-use coupled RF interference, which may be heard as audio frequency noises by the hearing aid wearer. The established standards are seen to be generally reasonable in meeting the compatibility goals (i.e., ensuring a low level of perceived audio interference), but the combined effects of the relative device positioning, the hand, and especially the head add a high degree of uncertainty to the relationship between the actual in-use RF interference coupling and predictions based on individual emissions and immunity measurements.

URL:
http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7407182&url=http%3A%2F%2Fieeexplore.ieee.org%2Fstamp%2Fstamp.jsp%3Ftp%3D%26arnumber%3D7407182

Journal of the American Academy of Audiology

The first of two companion papers examined primarily, the magnetic signal levels and, secondarily, the field orientations required for effective coupling to hearing aid telecoils. The second of the companion papers examined the magnetic signal-to-noise (S/N) ratios required to achieve specific levels of telephone usability by hearing aid wearers.

Together with results from prior studies, these papers provided a basis for the telecoil coupling portion of C63.19 and the subjective weighting component of the standard’s RF interference level and related MIF (modulation interference factor) measurements.

1) **Julstrom**, S.D.; **Kozma-Spytek**, L.K., **Isabelle**, S. " Telecoil-Mode Hearing Aid Compatibility Performance Requirements for Wireless and Cordless Handsets: Magnetic Signal Levels," in J Am Acad Audiol 22:515–527 (2011)

URL:
http://www.ingentaconnect.com/content/aaa/jaaa/2011/00000022/00000008/art00004?token=004c16c28b6879405847447b495b2f7b40386f7c47674c3633757e6f3f2f2730673f582f6b57

2) **Julstrom**, S.D.; **Kozma-Spytek**, L.K., **Isabelle**, S. " Telecoil-Mode Hearing Aid Compatibility Performance Requirements for Wireless and Cordless Handsets: Magnetic Signal-to-Noise," in J Am Acad Audiol 22:528–541 (2011)

URL:
http://www.ingentaconnect.com/content/aaa/jaaa/2011/00000022/00000008/art00005?token=0055189bc5e7abe36720297d7634737b2a7b6c7a3f424335746d3f6a4b6e4e395e4e6b6331d26ac98ded2

This third paper extended the human-subject tests to cochlear implant users, in both microphone and telecoil modes of device operation, and compared the results to those from hearing aid users:

3) **Julstrom**, S.D.; **Kozma-Spytek**, L.K., " Subjective Assessment of Cochlear Implant Users' Signal-to-Noise Ratio Requirements for Different Levels of Wireless Device Usability," in J Am Acad Audiol 25:952–968 (2014)

URL:
http://www.ingentaconnect.com/content/aaa/jaaa/2014/00000025/00000010/art00004?token=00591fa6808e10401e22003573d2570257044492b2f533125595e47747c4e7547543c7e386f642f466f78fe36