ELECTROMAGNETIC FIELD MEASUREMENTS FOR NON-IONIZING RADIATION HAZARDS

by

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Background

1. All electrodynamic measurements involve some compromise between the required information and the parameters that can be conveniently measured. This compromise is particularly evident in the measurement of electromagnetic fields. The general complexity of the problem is well understood.[1,2,3,4] Moreover, it is possible completely to determine the magnitudes and relative phases of all the vectors of an elliptically polarized field.[5] However, the traditional approach — a hang-over from the simplistic philosophies of the far field, plane wave EMI era — has been to measure some average magnitude of one field vector, usually the more conveniently sampled electric vector. Acknowledging the fact that power density has no relevance in near field and complicated field hazard determinations, the modern trend has been towards "energy density", the physical reality of which, in time-variant fields, can neither be proved nor disproved.[6] Recent in-house research at NWL has confirmed that the "energy density" in the near field migrates during each cycle between zones separated by a fraction of a wavelength.

2. In biological hazards there are both thermal and athermal effects, the latter probably being a function of instantaneous field intensity magnitudes and the relative phase between E and H components. Dosimetry involves the determination of both unperturbed fields and the localized total fields inside a subject, so that field surveys may be correlated with laboratory experiments. Because so little is known about direct field-induced, biological effects, it is necessary to measure not only CW fields but also high intensity single pulse fields, fields with repetitive short pulses and fields with complicated long-term modulations. It must be stressed that we are now generating, at NWL, high intensity transient fields which we cannot satisfactorily measure. Our peak power capabilities will increase drastically in the near future — up to atmospheric breakdown levels. A research program in the area of biological hazards of such fields is now in the planning stage.

General Requirements for Field Measuring Instruments

3.

a) The ultimate frequency range of the complete family of instruments should be 0-3000 GHz (ERMAC Report)

b) Research instruments, for use in anechoic chambers should measure the magnitudes and relative phase of both E and H in CW fields and the peak values of these components in transient fields. A time-response not greater than one nanosecond is required, with peak-holding.

c) General purpose dosimetry and field survey instruments should measure squared magnitudes of E and H, or the so-called "energy density".

d) The range of intensities required (not necessarily in the same instrument) is from those of currently specified environments through breakdown intensities at sea-level atmospheric pressure (approx. 23 Kv/cm or 1.4 Mw/cm^2 - plane wave).

e) For general field survey and dosimetry, the probe response should be independent of its angular orientation in the field.

f) The probe should be very much smaller than a wavelength and should be able to resolve the fine structure of the field ("hot spots").

g) The probe should perturb the field minimally.

First Priority Tasks

4. Because the total spectrum of the problem is very broad, the following short list of top priority tasks is proposed:

a) A broad-band electric field "energy density" probe, or range of probes (3 crossed dipoles) -3 MHz to 12 GHz suitable for both normal and high intensity fields applicable to on-going research at NWL and NOL. Both CW average and nanosecond transient response with peak-holding are design goals.

b) A micro-miniature inplantable probe with non-perturbing read-out capabilities (NBS high-resistivity plastic transmission line, light-pipe, fluidic, acoustic or other non-metallic means).

c) A personal, lapel-type monitor probe (possibly based on the isotropic gas-tube or gas bolometer).

d) The magnetic dual of item (a) (3 crossed loops).

e) A research probe to measure the magnitudes and phases of both E and H in elliptically polarized fields (probably based on Navy Patent).[5]

A Co-ordinated Plan

5. There is considerable commonality between the biological hazards area and the electronic systems/weapon vulnerability areas, in which we are deeply involved. These complementary animate/inanimate facets of weapon systems are unified by their common electromagnetic environment. There is, therefore, considerable scope for economics in R.D.T. and E. facilities, test equipment development and management.

6. NWL has been active in this area for over 14 years and has collaborated with NBS on several occasions. Taking into account the on-going developments in related areas, particularly in the Air Force, Army* and Bureau of Radiological Health (Department of Health, Education and Welfare). We, therefore, propose to develop, in the next few weeks, a detailed program proposal, in conjunction with NBS, Boulder, Colorado, for early submission to the Non-Ionizing Co-ordinating Committee (NAVMAT). We have had preliminary discussions with Dr. Ramon C. Baird - Chief of the Electromagnetics, Fields and Antennas Section of NBS, Boulder (Copy of letter attached).

References

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4. Electromagnetic Near Field Coupling to Aircraft Systems (0-32 MHz) - Reginald Irvan Gray - NWL - Technical Report TR-2482 - Oct 1970

5. U.S. Patent No. 3,611,382 - 5 Oct 1971 "Detector Probe for Measurement of High-Frequency Elliptically Polarized Fields" - Reginal Irvan Gray - USNWL

6. Electromagnetic Theory - Julius Adams Stratton - McGraw-Hill (New York) 1941 - pp. 110-133

*According to DOD Directive 3222.3, July 5, 1967 the Secretary of the Army has overall co-ordinating responsibility