EM Site A.C. Magnetic Field Sources, Surveys and Solutions Part III: Survey Instrumentation and Methods:

Curt R. Dunnam, Linear Research Associates

A.C. magnetic fields exist throughout every EM site. For a given site, then, how does one predict when EM interference problems are likely to occur? Obviously, an accurate, meaningful magnetic field survey is the first step toward evaluating site EM magnetic field compatibility. Consequently, this article in our series will describe measurement equipment and techniques for achieving accurate, unambiguous magnetic field characterization.

In a previous article (Part II: "ACMF/EM Antipathy", *Microscopy Today*, November '95), we examined several types of sources which produce alternating current magnetic fields (ACMFs). In near proximity, or at sufficiently high power levels, any of these sources (e.g., transformers, power cabling, ground currents, and/or combinations thereof) can affect EM operation. In this article, we will review specific instrumentation and methods for accurate magnetic field survey data collection and interpretation, a necessary prior step for EM interference prediction and resolution.

Moving beyond conventional A.C. magnetic field survey equipment and techniques, we will also briefly examine low-frequency (LF) survey methods. LF magnetic field perturbations are due to the movement of trains, vehicular traffic and elevators or, less frequently, the proximity of high-power D.C. equipment. Because LF field variations caused by these sources do not register on standard A.C. magnetic survey apparatus, special equipment and measuring procedures are required.

Insofar as line-operated A.C. magnetic field sources are concerned, it should be obvious that an understanding of source ACMF characteristics can prove useful when planning a site. Buss trays and conduits, for example, can be routed away from a prospective EM location prior to actual construction. Similarly, power distribution transformers can be relocated, etc. (ref. previous article for applicable data). However, not every ACMF source can be anticipated. In practice, it is nearly impossible to identify significant ground-current-induced A.C. magnetic sources by inspection, even in the case of new construction. This difficulty stems mainly from the unpredictability of electrical and magnetic induction into, and resultant current paths through, building gounding systems and structural elements. Even in recently-constructed buildings where reasonable attention has been paid to routing of busses and location of distribution transformers, the unpredictability of ground currents mandates one or more ACMF surveys prior to site certification.

Goals of an ACMF survey are twofold; first and most important is accurate determination of environmental field levels, including low-frequency geomagnetic variations if the site is situated in an urban or large-building setting. The second goal is laying a foundation for efficient resolution of any high-field problems which may be uncovered. Attaining the first goal is straightforward and may be accomplished, for line-frequency ACMF's, with sufficient accuracy by employing apparatus as simple as a hand-held gaussmeter. Achieving the second goal implies data-taking methods of adequate resolution to permit unambiguous identification of problem sources and, in some cases, identification of a usable alternate location within a site. Complete data records will also aid in determining the feasibility of active and/or passive shielding solutions.

Equipment and methodology are, of course, related. A tri-axial hand-held milligaussmeter (viz. Teslatronics Model 70) is the instrument of choice for a quick sweep of the proposed EM site (so-called "field coils" are a distinctly inferior alternative for this application due to their frequency sensitivity and directivity). Sweeping is an essential initial survey step in any formal site qualification procedure. A sweep implies smoothly working the hand-held instrument back and forth across an area to be surveyed, mentally noting high, low and average values on an imaginary plane at approximately 1 m (waist) height. Anomalous local "hot spot" readings are noted for future reference and, with the same instrument, traced back to the source(s). If an FEG installation is anticipated, the ceiling area at arm's reach is also swept and the same recording and tracing procedure followed.

With the site ACMFs at least qualitatively understood and any problematic local sources identified, the survey engineer divides the room into four or six measurement quads with a small marker identifying the center of each quad and, next, prepares a survey form. Our standard survey form includes, for example, a sketch of the room with subdivision lines and a reference coordinate system, to which the survey engineer adds dimensions, room details and notation describing known ACMF sources. Information indicating the type of measurement equipment used, range settings and signal weighting is also entered before continuing with the survey work.

For line frequency (1.6 Hz to 1.6 KHz) ACMF data collection, either a single-axis (or selectable single-axis) hand-held gaussmeter or a tri-axial (Bartington MAG-03) probe-based fluxgate system such as illustrated in Figure 1 can be used. In either case, x-, y-, and z- axis values are recorded for each quad and at near the proposed EM column location at a 1.0 m height. If the

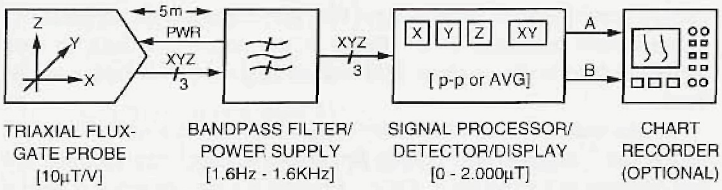

Figure 1 - "A.C." magnetic field survey system.

measurement equipment displays Bxy or Bxyz vector magnitudes these figures are also recorded. If not, they are calculated later. Generally, mid-morning or afternoon collection of ACMF values presents a reasonable assurance of capturing worst-case data. However, if it is suspected that ACMF values are changing appreciably over time, the more versatile fluxgate "A.C." system can be configured with an optional chart recorder. Time-log measurements should be taken at the proposed EM column position or, alternatively, near the center of the room away from strong local sources.

A final series of low-frequency "D.C." measurements is required in urban or large-building environments. In these settings, 0.5 - 2.0 uT peak-to-peak (5 - 20 milligauss) magnetic variations covering a range of 0.001 to 1 Hz are inevitability present. Consequently, an A.C.-line field survey alone is almost certain to yield an incomplete picture of possible magnetic field-EM interference. Fortunately, however, low-frequency measurements are straightforward and may be made with the same tri-axial fluctuate probe used in line-frequency ACMF surveys. A high-accuracy, relatively inexpensive D.C. to 1.6 Hz fluxgate probe system based on this principle is illustrated in Figure 2. In this "D.C." survey configuration, lowpass filter and offset summer modules are used to define the frequency range

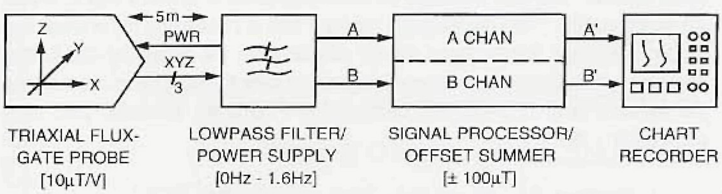

Figure 2 - "D.C." magnetic field survey system.

of interest and cancel out axial geomagnetic field components. With the fluxgate probe set in place at the room center and adjusted to 1.0 m height, system outputs representing two (observed) worst-case axes are routed to a dual-channel chart recorder. A relatively high resolution (0.5 cm/min) time-log is recorded for two hours during the business day followed by a 24 hour record at a somewhat lower (4 cm/hr.) rate. In subsequent analysis of the chart tracings, both short-term and diurnal information are relevant to site qualification.

In the next article we will discuss interpretation of A.C.-line and LF magnetic field survey data and the role of survey data analysis in resolution of excessive EM site ACMFs.

Questions relating to this series are welcomed and may be faxed, along with survey form requests, to the author's attention at Linear Research Associates, USA: (607)387-7806. ■