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Center for Electronics and Electrical Engineering

Technical Publication Announcements

Covering Center Programs, April to June 1986 with 1987 CEEE Events Calendar

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INTRODUCTION TO THE CEEE TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the ninth issue of a quarterly publication providing information on the technical work of the National Bureau of Standards Center for Electronics and Electrical Engineering. This issue of the CEEE Technical Publication Announcements covers the second quarter of calendar year 1986.

Organization of Bulletin: This issue contains citations and abstracts for Center papers published in the quarter. Entries are arranged by technical topic as identified in the table of contents and alphabetically by first author within each topic. Following each abstract is the name and telephone number of the individual to contact for more information on the topic (usually the first author). This issue also includes a calendar of Center conferences and workshops planned for calendar year 1987 and a list of sponsors of the work.

Center for Electronics and Electrical Engineering: Center programs provide national reference standards, measurement methods, supporting theory and data, and traceability to national standards.

The metrological products of these programs aid economic growth by promoting equity and efficiency in the marketplace, by removing metrological barriers to improved productivity and innovation, by increasing U.S. competitiveness in international markets through facilitation of compliance with international agreements, and by providing technical bases for the development of voluntary standards for domestic and international trade. These metrological products also aid in the development of rational regulatory policy and promote efficient functioning of technical programs of the Government.

The work of the Center is divided into two major programs: the Semiconductor Technology Program, carried out by the Semiconductor Electronics Division (formerly the Semiconductor Materials and Processes and the Semiconductor Devices and Circuits Divisions) in Gaithersburg, MD, and the Signals and Systems Metrology Program, carried out by the Electrosystems Division in Gaithersburg and the Electromagnetic Fields and Electromagnetic Technology Divisions in Boulder, CO. See the table of contents on the opposite page for identification of the topics covered by each program, as represented in this issue. Key contacts in the Center are given on the back cover; readers are encouraged to contact any of these individuals for further information.

Center sponsors: The Center Programs are sponsored by the National Bureau of Standards and a number of other organizations, in both the Federal and private sectors; these are identified on page 16.

Note on Publication Lists: Guides to earlier as well as recent work are the publication lists covering the work of each division. These lists are revised and reissued on an approximately annual basis and are available from the originating division. The current set is identified in the Additional Information section, page 13.

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SEMICONDUCTOR TECHNOLOGY

Analysis Techniques

Baghdadi, A., Gladden, W.K., and Flach, D.R., **Nonlinear Effects of Digitizer Errors in FT-IR Spectroscopy**, Appl. Spectroscopy, Vol. 40, No. 5, pp. 617-628 (1986).

This paper is an investigation of the effects of errors in the analog-to-digital converter (ADC) of a Fourier transform infrared (FT-IR) spectrometer on the photometric accuracy of that spectrometer. The effect of ADC errors on the spectrum after Fourier transformation are calculated analytically for monochromatic, two-line and wide square band emission spectra. Numerical modeling is used to extend the analysis to absorption spectra, and to include the effects of noise on the amplitude of absorbance bands. These analyses show that ADC errors can generate artifacts throughout the spectrum, although the largest effects occur at sharp spectral features. Errors as large as 8% in the amplitude of absorbance bands can be produced by ADC errors of one least significant bit (LSB), in a 15-bit ADC. These results were confirmed qualitatively by measuring the net height of the oxygen vibrational band in silicon at 1107 cm^{-1} using four different ADC circuit boards in the same FT-IR spectrometer. At the highest signal levels, the boards disagreed by as much as 4%, even though the static transfer characteristics of the ADC boards (which were measured in a separate experiment) exhibited errors of less than ±2 LSBs.
[Contact: Aslan Baghdadi, (301) 975-2062]

Dimensional Metrology

Chandler-Horowitz, D., **Semiconductor Measurement Technology: Analytic Analysis of Ellipsometric Errors**, NBS Special Publication 400-78 (May 1986).

A computer program is given that contains an explicit ellipsometric error analysis. The program can identify the ellipsometric inaccuracies for any ellipsometer, can be used to determine which parameters contribute the most to the overall measurement inaccuracy, and can lead one to an optimum measurement procedure. A FORTRAN program that performs the evaluation of the partial derivative expressions needed to analyze ellipsometric measurement uncertainties is listed. The program determines the uncertainty in the calculation of the refractive index of a bare isotropic substrate or the uncertainty in the determination of the thickness and refractive index of a nonabsorbing film on a substrate of known refractive index. These are the two most commonly used surface models used in ellipsometry performed at a single angle of incidence and a single wavelength. The program input parameters include the wavelength of the light, the angle of incidence and its uncertainty, and the uncertainties in the ellipsometric parameters Δ and ψ. They also include in the ambient-substrate model an estimated value for the substrate's refractive index, and in the film-substrate model the refractive index of the substrate and its uncertainty and estimated values for the film's refractive index and thickness. The case of the conventional null ellipsometer utilizing a quarter-wave plate is treated to find the uncertainties in Δ and ψ from the uncertainties in the polarizer and analyzer null values and the waveplate constants.
[Contact: Deane Chandler-Horowitz, (301) 975-2084]

Nyyssonen, D., **Linewidth Calibration for Bright-Chromium Photomasks**, NBSIR 86-3357 (May 1986).

Linewidth measurement errors are introduced when an anti-reflective (AR) chromium photomask standard such as the NBS SRM 474/475 is used to calibrate an optical linewidth measurement system for subsequent measurements on another material such as bright chromium whose optical properties (index of refraction, thickness, reflectance, and edge geome-

Dimensional Metrology, cont'd.

try) do not match those of the calibration standard. In addition to differences in the optical properties of the materials, the magnitude of these errors varies from system to system and depends upon resolution, choice of edge-detection criterion, flare light in the optical system, and detector response. These errors are greatest when measurements are made in reflected light due to the greater sensitivity to the mismatch in optical parameters of the materials between the calibration standard (AR-chromium) and the material to be measured (bright chromium). This report, therefore, recommends use of transmitted light for linewidth measurements on photomasks and as close a match as possible between the material parameters of the calibration standard and those of the part being measured in order to ensure a realistic assessment of the accuracy and precision of subsequent measurements.
[Contact: Robert D. Larrabee, (301) 975-2298]

Process and Device Modeling

Hefner, A.R., and Blackburn, D.L., **Performance Trade-Off for the Insulated Gate Bipolar Transistor: Buffer Layer Versus Base Lifetime Reduction,** 1986 Power Electronics Specialists Conference, Vancouver, British Columbia, Canada, June 23, 1986, pp. 27-38 (1986).

A one-dimensional analytic model for the Insulated Gate Bipolar Transistor (IGBT) which includes a high-doped buffer layer in the low-doped bipolar transistor base is developed. The model is used to perform a theoretical trade-off study between IGBTs with and without the buffer layer. The study is performed for devices of equal breakdown voltages, and the critical parameters chosen to "trade-off" are turn-off switching energy loss (related to turn-off time) and on-state voltage, both at a given current. In this study, as in reality, the two critical parameters are varied by: 1) adjusting the doping concentration and thickness of a buffer layer included as part of the bipolar transistor base, 2) adjusting the lifetime in the low doped bipolar transistor base with no buffer layer included, or by 3) a combination of 1) and 2). The results of the model predict that for equal breakdown voltages, an optimized device with a buffer layer has less switching energy loss for a given on-state voltage than an optimized device with no buffer layer.
[Contact: Allen R. Hefner, (301) 975-2071]

Wachnik, R.A., and Lowney, J.R., **A Model for the Charge-Pumping Current Based on Small Rectangular Voltage Pulses**, Solid-State Electronics, Vol. 29, No. 4, pp. 447-460 (1986).

The charge-pumping current results from recombination associated with the SiO_2-Si interface traps under the gate of a metal-oxide-semiconductor field-effect transistor (MOSFET) when a voltage pulse is applied to the gate. A model is proposed which predicts this current as a function of the frequency, amplitude, and average voltage of pulses with peak-to-peak amplitudes less than the difference between the flatband and inversion voltages and with pulse transitions fast enough so that negligible capture or emission occurs during the transition. The model is based on Shockley-Read-Hall traps segregated by energy and capture cross section into traps which capture only and traps which tend to emit before capture. It predicts the dominant behavior of the measured current and with the inclusion of surface potential fluctuations and a distribution of cross sections it agrees very well with experiment. Thus, the charge pumping current due to these small rectangular pulses can be used to determine the density, the electron capture cross section, and the hole capture cross section of interface traps near midgap.
[Contact: Jeremiah R. Lowney, (301) 975-2048]

FAST SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

Waveform Metrology

Gans, W.L., **Calibration and Error Analysis of a Picosecond Pulse Waveform Measurement System at NBS**, Proceedings of the IEEE, Vol. 74, No. 1, pp. 86-90 (January 1986).

The primary system used at NBS, Boulder, CO, to measure fast (picosecond-nanosecond range), repetitive, electric pulse parameters consists essentially of a wide-band (dc -18 GHz) sampling oscilloscope interfaced to a minicomputer. This paper describes the major calibration and analysis techniques used to reduce the effects of errors inherent in this system, both deterministic and random in nature.
[Contact: William L. Gans, (303) 497-3538]

Lawton, R.A., **An Efficient Antialiasing Filter**, IEEE Transactions on Instrumentation and Measurement, Vol. IM-34, No. 4., pp. 570-573 (December 1985).

The application of a solid-state reference filter as an efficient antialiasing filter is described. The analytical basis for the efficiency of this filter is described and a specific example of measuring a 1024-point waveform with a resistance-capacitance (RC) filter network and the solid-state filter is given.
[Contact: Robert A. Lawton, (303) 497-3339]

Souders, T.M., Flach, D.R., and Schoenwetter, H.K., **Transient Respons Characterization of Waveform Recorders**, Proceedings of the 5th IEE Pulsed Power Conference, Arlington, Virginia, June 10-12, 1985, pp. 352-355 (May 1986).

Test methods for characterizing the transient response of waveform recorders are presented, together with typical test results. The methods, based on the use of a precision, programmable step generator developed at NBS, are suitable for recorders having up to 10 bits of resolution and 100 MHz bandwidth.
[Contact: T. Michael Souders, (301) 975-2406]

Turgel, R.S., **NBS 50 kHz Phase Angle Calibration Standard**, NBS Technical Note 1220 (April 1986).

A detailed description is given of the features of an electrical phase angle calibration standard designed for operation over a frequency span of 2 Hz to 50 kHz. The phase resolution of this calibrator extends from just below 2 millidegrees at the low end of the frequency range to about 5 millidegrees at the high end. The uncertainty in the phase angle is a function of frequency, amplitude, and amplitude ratio of the two outputs. It varies from 5 to 50 millidegrees.
[Contact: Raymond S. Turgel, (301) 975-2420]

Cryoelectronic Metrology

Clark, A.F., **Conference Report on the Tenth International Cryogenic Engineering Conference**, Cryogenics, Vol. 25, pp. 222-223 (April 1985).

The tenth International Cryogenic Engineering Conference was held in Otaniemi, Finland, 31 July to 3 August 1984, hosted by the Helsinki University of Technology. More than 300 attendees representing 22 countries contributed 220 papers on such diverse subjects as sensing human brainwaves from their magnetic fields to superconducting magnets the size of railroad cars and to ultralow temperature refrigerators which can achieve nuclear temperatures of the order of nanokelvin. The special topic for this conference was cryogenics in medicine, and thus many of the plenary talks covered cryosurgery, magnetic resonance imaging, SQUID magnetometers for heart and brain waves, and biological preservation.
[Contact: Alan F. Clark, (303) 497-3253]

Cryoelectronic Metrology, cont'd.

Hamilton, C.A., Kautz, R.L., and Lloyd, F.L., **A Josephson Series Array Voltage Standard at One Volt,** NCSL 1985 Workshop & Symposium, Boulder, Colorado, July 15-18, 1985, pp. 71-77.

Josephson voltage standards have long been limited by their low 1- to 10-mV output level. A new method for operating 1000 or more Josephson junctions in series has produced a practical standard at the 1-V level. The junction array is in the form of a microstrip which is finline coupled to a waveguide at one end and is terminated at the other end. The whole circuit is fabricated on a 6 by 12 mm silicon substrate. With applied radiation at 72 GHz, the junction array produces up to 8000 quantized levels at the voltages nhf/2e. (In the U.S. 2e/h has an assigned value of 483593.420 GHz/V_{NBS}.) By selecting the level, n, and fine tuning the frequency, f, any voltage from 0.1 to 1.2 V can be obtained. The high output voltage eliminates the need for a voltage divider and greatly reduces errors due to thermal voltages. When fully evaluated, the new standard is expected to have a precision of a few parts per billion.
[Contact: Clark A. Hamilton, (303) 497-3740]

Hamilton, C.A., Kautz, R.L., Lloyd, F.L., and Steiner, R.L., **A Practical Josephson Voltage Standard at 1 V,** IEEE Electron Device Letters, Vol. EDL-6, No. 12, pp. 623-625 (December 1985).

A series array of 1484 pairs of Josephson junctions biased by microwaves at 72 GHz is demonstrated to provide stable quantized voltages at the 1-V level. The niobium/lead-alloy junctions used in the array are not affected by thermal cycling.
[Contact: Clark A. Hamilton, (303) 497-3740]

Antenna Metrology

Jesch, R.L., **Measured Vehicular Antenna Performance,** National Institute of Justice Report-201-85 (May 1986). [A similar paper by the same title appeared in IEEE Transactions on Vehicular Technology, Vol. VT-34, No. 2, pp. 97-107 (May 1985).]

Power gain radiation patterns of mobile antennas mounted in six different locations on a test vehicle were measured with and without typical lights and sirens mounted on the roof. The measurements were performed at frequencies representing the frequency bands of 25 to 50, 150 to 174, 400 to 512, and 806 to 866 MHz. In addition, the radiation patterns were measured of three disguised antennas operating at discrete frequencies of 40.27, 162.475, and 416.975 MHz and one slot antenna operating at 413 MHz. Plots of power gain radiation patterns are given for the mobile antennas mounted in six different locations on the test vehicle, for the other four antennas, and to show the effects of improper grounding of the trunk lid and of the lights and siren. Recommended antenna mounting locations are identified for specific frequency bands and an appendix of power gain measurement data is included.
[Contact: Ramon L. Jesch, (303) 497-3496]

Kanda, M., Chang, D.C., and Greenlee, D.H., **The Characteristics of Iris-Fed Millimeter-Wave Rectangular Microstrip Patch Antennas,** IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-27, No. 4, pp. 212-220 (November 1985).

The fabrication of various iris-fed millimeter-wave rectangular microstrip patch antennas is described. A mathematical model is proposed to describe the iris-fed antenna. An iris having 15% of the area of the patch is used to couple energy into the antenna. Resonance of the antenna is observed to be insensitive to the size of the iris for irises up to 115% of the size of the patch. A study is also made of the

Antenna Metrology, cont'd.

coupling to the antenna as a function of position of the iris with respect to the transverse plane of the waveguide, the iris always being centered with respect to the patch. In general, the antenna has a VSWR in the waveguide feed of roughly 5:1 at resonance, except for the fully open waveguide which gives rise to a VSWR of 2.9:1 at resonance. Far-field antenna power patterns are observed to be quite broad with H-plane beamwidths about 130°. Maximum antenna gain observed was 4.5 dB relative to an isotropic source (dBi), with 2 dBi typical. An initial study is made of the microstrip patch antenna fed from a longitudinal waveguide wall. Results indicate that this feed structure is likely to prove valuable for microstrip patch antennas, with coupling at least as good as for the transverse-fed patch, added to the possibility of feeding multiple patches from a single waveguide.
[Contact: Motohisa Kanda, (303) 497-5320]

Microwave & Millimeter-Wave Metrology

Holt, D.R., and Hoer, C.A., **Estimation of True Power Ratios in Six-Port Network Analyzers Using Diode Detectors,** IEEE Transactions on Instrumentation and Measurement, Vol. IM-34, No. 4, pp. 558-563 (December 1985). [A shortened version of this paper appeared in the Proceedings of the IEEE Instrumentation and Measurement Technology Conference, Tampa, Florida, March 20-22, 1985, pp. 140-141.]

A model for detector nonlinearity is included in the determination of six-port parameters without using additional standards. A computer simulation was performed assuming that the true power performed assuming that the true power into each six-port detector is related to the power observed by the detector. Simultaneous estimation of the six-port and detector parameters is accomplished through a nonlinear least-squares algorithm. Results of the simulation compare the reflection coefficient Γ computed from corrected power readings and Γ calculated from observed power readings.
[Contact: Donald R. Holt, (303) 497-3574]

Laser Metrology

Rasmussen, A.L., and Sanders, A.A., **Transfer Standards for Energy and Peak Power of Low-Level 1.064 Micrometer Laser Pulses and Continuous Wave Laser Power,** Optical Engineering, Vol. 25, No. 2, pp. 277-285 (February 1986).

For the first time, traceable transfer standards have been developed for measuring 1.064-μm laser pulses having durations of about 10 to 100 ns, peak power densities of about 10^{-8} to 10^{-4} W/cm^2, and energy density of about 10^{-16} to 10^{-11} J/cm^2. These power and energy transfer standards use silicon avalanche photodiode (APD) and PIN photodiode detectors, respectively (PIN refers to the detailed semiconductor structure: a "sandwich" of p-conductivity type material, intrinsic layer, and n-conductivity type material). These standards are stable and have total uncertainties of about 10%. The system for calibrating them and other devices consists of a continuous wave (cw) Nd:YAG laser beam acousto-optically modulated to provide low-level laser pulses of known peak power and energy. Using a pulse-height analyzer readout, the PIN transfer standard system records each pulse, from which the mean pulse energy and laser stability may be evaluated. Using an integrating voltmeter readout, this system can measure energy or average power. These pulsed and cw measurement techniques can be extended to the visible and other near-infrared wavelengths.
[Contact: Alvin L. Rasmussen, (303) 497-5367 or -3616]

Optical Fiber Metrology

Rasmussen, A.L., and Franzen, D.L.,

Optical Fiber Metrology, cont'd.

Low-Level Germanium Detector Transfer Standard at 1.064 µm, NBSIR 85-3041 (January 1986).

Two PIN germanium photodiodes have been calibrated in the 1- to 250-fJ/cm^2 range with 15 percent uncertainty for 10- to 100-ns duration, 1.064-µm laser pulses [PIN refers to a "sandwich" structure of a layer of p-conductivity type material, an intrinsic layer, and an n-conductivity type layer]. To do these calibrations, we used (1) a continuous wave Nd:YAG laser beam acousto-optically modulated and a PIN silicon photodiode transfer standard to provide low-level laser pulses of known energy and (2) a pulsed 1.06-µm LED beam. A 1-cm^2 collecting lens and a ground glass diffuser were placed in front of each detector to improve sensitivity and spatial uniformity, respectively. In the future, these detectors may also be useful as transfer standards at wavelengths out to 1.7 µm.
[Contact: Alvin L. Rasmussen, (303) 497-5367 or -3616]

Electro-Optic Metrology

Hebner, R.E., **Electro-Optical Measurement Techniques,** Fast Electrical and Optical Measurements, Vol. 1, pp. 5-25 (Martinus Nijhoff, Boston, MA, 1986) [Proceedings of the NATO Advanced Study Institute on Fast Electrical and Optical Diagnostic Principles and Techniques].

This paper reviews the use of the Faraday effect, the Pockels effect, and the Kerr effect to measure electric fields, magnetic fields, voltages, currents, and space charge density. Each of the three effects is introduced conceptually, the use of Jones or Mueller matrices to describe the optical system is presented, and some applications of these effects are described.
[Contact: Robert E. Hebner, (301) 975-2403]

Other Fast Signal Topics

Laug, O.B., Stenbakken, G.N., and Leedy, T.F., **Electrical Performance Tests for Audio Distortion Analyzers,** NBS Technical Note 1219 (January 1986) [previously published as NBSIR 85-3269 (November 1985)].

Electrical performance test procedures for audio distortion analyzers were developed by the National Bureau of Standards for the U.S. Army Communications-Electronics Command. The report provides detailed, step-by-step test procedures that are based on specifications supplied by the Army for purposes of evaluating audio distortion analyzer bid samples. Examples of data sheets and tables are also provided for recording interim and final results.

The report discusses the philosophy of each measurement procedure with a view toward providing an understanding of the basic metrology required to perform the measurements. In addition, the sources of measurement error are discussed. The primary applications and basic principles of modern audio distortion analyzers are also presented.
[Contact: Owen B. Laug, (301) 975-2412]

Miller, C.K.S., Taggart, H.E., and Bensema, W.D., **Mobile FM Transceivers,** National Institute of Justice Standard-0210.00 (May 1986).

The purpose of this document is to establish performance requirements and methods of test for non-trunked, frequency modulated (FM) mobile transceivers. This standard applies to transceivers which either do not have special subsystems such as selective signaling or voice privacy, or in which such subsystems are bypassed or disabled during testing for compliance with this standard. This standard supersedes NILECJ-STD-0202.00, Mobile FM Transmitters and NILECJ-STD-0207.00, Mobile FM Receivers.
[Contact: Mark T. Ma, (303) 497-3800]

Other Fast Signal Topics, cont'd.

Miller, C.K.S., Taggart, H.E., Jesch, R.L., and Wainright, A.E., **Personal/Mobile FM Transceivers,** National Institute of Justice Standard-0224.00 (May 1986).

The purpose of this document is to establish performance requirements and methods of test for non-trunked, frequency modulated (FM) personal/mobile transceivers. This standard applies to personal transceivers with rechargeable batteries and personal/mobile transceivers which use a charger/mobile unit, with or without an rf power amplifier, and which either do not have special subsystems such as selective signaling or voice privacy, or in which such subsystems are bypassed or disabled during testing for compliance with this standard. The individual personal FM transceivers are expected to meet the minimum performance requirements as established in NIJ Standard-0209.01 for Personal FM Transceivers prior to being tested for the requirements of this standard. Due to the lack of use of personal/mobile transceivers in the 25 to 50 MHz and 806 to 866 MHz frequency bands, requirements for these transceivers are not included in this standard.
[Contact: Mark T. Ma, (303) 497-3800]

ELECTRICAL SYSTEMS

Power Systems Metrology

Anderson, W.E., Ramboz, J.D., and Ondrejka, A.R., **Final Report: Technical Contributions to the Development of Incipient Fault Detection/Location Instrumentation,** NBSIR 86-3392 (April 1986).

The transmission of electrical energy by use of underground cables is increasing. Fault location techniques have certain limitations; incipient fault detection and location would help reduce the maintenance cost of these lines as well as improve the reliability of service. This report discusses some test results related to radio-frequency (rf) probing techniques applied to high-voltage transmission lines. The high-frequency losses and attenuation in high-voltage cables places certain ultimate limitations on rf-probing techniques for incipient fault detection. Time-domain reflectrometry methods were employed to assess the rf-transmission properties of high-voltage cables at frequencies up to 6 GHz. Fast Fourier transform deconvolution was used to obtain loss measurements as a function of frequency. The loss mechanisms were identified. The measurement hardware and methods are discussed as well as analysis approach leading to the conclusions.
[Contact: William E. Anderson, (301) 975-2423]

Hebner, R.E., **Electro-Optical Measurement Techniques,** Fast Electrical and Optical Measurements, Vol. 1, pp. 5-25 (Martinus Nijhoff, Boston, MA, 1986) [Proceedings of the NATO Advanced Study Institute on Fast Electrical and Optical Diagnostic Principles and Techniques].

This paper reviews the use of the Faraday effect, the Pockels effect, and the Kerr effect to measure electric fields, magnetic fields, voltages, currents, and space charge density. Each of the three effects is introduced conceptually, the use of Jones or Mueller matrices to describe the optical system is presented, and some applications of these effects are described.
[Contact: Robert E. Hebner, (301) 975-2403]

Kelley, E.F., Hebner, R.E., Fitzpatrick, G.J., and Forster, E.O, **The Effect of Pressure on Streamer Initiation in n-Hexane,** Proceedings of the 1986 IEEE International Symposium on Electrical Insulation, Washington, DC, June 9-12, 1986, pp. 66-68.

High-speed photographs of the breakdown process at pressures in the range 0.1 to 10 MPa indicate that the structure of

Power Systems Metrology, cont'd.

the streamer changes with the pressure. The typical structures associated with primary streamers are no longer visible at elevated pressures. Over this range, the average cathode streamer velocity increases from about 0.25 km/s to 2.5 km/s. The anode streamer, however, does not generally exhibit a bushy primary streamer structure, and its velocity appears to be less affected by pressure.
[Contact: Edward F. Kelley, (301) 975-2424 or -5826]

Misakian, M., McKnight, R.H., and Fenimore, C., **Calibration of Aspirator-Type Ion Counters and Measurement of Unipolar Charge Densities**, NBS Technical Note 1223 (May 1986).

The characterization of a parallel-plate apparatus which can produce a unipolar ion density that is suitable for calibrating aspirator-type ion counters operating in the ground plane is described. The influence of a dc electric field, air motion, Coulomb repulsion, and diffusion on the transport of ions into the ion counter are examined to determine their effects on instrument calibration and measurements in the vicinity of high voltage dc transmission lines. An ion density which is known with an uncertainty of less than ±9% is used to check the performance of an ion counter with and without a duct at its entrance. The results of laboratory measurements of ion density under a monopolar high voltage line, which complement the studies with the parallel-plate apparatus, are also described.
[Contact: Martin Misakian, (301) 975-2426]

Siddagangappa, M.C., Van Brunt, R.J., and Phelps, A.V., **Influence of Oxygen on the Decomposition Rate of SF_6 in Corona**, Proceedings of the 1986 IEEE International Symposium on Electrical Insulation, Washington, DC, June 9-12, 1986, pp. 225-229.

The absolute charge rates-of-production of discharge generated gaseous by-products SOF_4, SOF_2, SO_2F_2, SO_2, and CO_2 have been measured in compressed SF_6/O_2 mixtures at a constant pressure. The normalized total rate of oxyfluorides plus SO_2 production per SF_6 mole does not increase significantly with the addition of O_2 up to 50% in SF_6 and increases slowly for $[O_2]>50\%$. The formation of SO_2 in all SF_6/O_2 mixtures was insignificant. Instead, the deposition of sulfur (S^- ions) on the anode increased with O_2 concentration. The yield of CO_2 from oxidation of carbon on the electrode was also observed to increase with O_2 content. Probable mechanisms for the formation of SOF_2, SO_2F_2, SOF_4, S^- ions, and CO_2 are discussed. The measured by-product yield as a function of percent O_2 is compared with the calculated maximum rate of SF_6 decomposition induced by electron collision in the discharge. The theoretical model used to calculate the rate of SF_6 decomposition in SF_6/O_2 mixtures is briefly discussed. As observed for SF_6/N_2 and SF_6/Ne mixtures, the primary effect of O_2 on SF_6 decomposition appears to be retardation of the recombination of SF_6 dissociation products due to dilution.
[Contact: Richard J. Van Brunt (301) 975-2425]

Van Brunt, R.J. **Water Vapor-Enhanced Electron-Avalanche Growth in SF_6 for Nonuniform Fields**, J. Appl. Phys., Vol. 59, No. 7, pp. 2314-2323 (April 1, 1986).

When water vapor content is increased from 10 to 100 ppm in SF_6 at pressures from 200 to 300 kPa, a dramatic enhancement occurs in the mean size of electron avalanches formed near a positive-point electrode. Although this effect can be attributed to a change in gas composition, it is not due to a change in the ionization rate for the gas. It is proposed that the avalanche enhancement is due primarily to an increase in the probability for initiating electron release from minor negative ions associ-

Power Systems Metrology, cont'd.

ated with water vapor that collisionally detach more readily at a given field strength than the predominant negative ions associated with SF_6. The profiles of the electron avalanche size distributions exhibit a monotonic decrease of probability with increasing number of electrons for avalanches with fewer than 10^7. These peaks are not consistent with the behavior expected from a stochastic model of electron-avalanche growth in nonuniform electric fields which neglects the influence of space charge.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Pulse Power Metrology

Hebner, R.E., **High-Speed Data Systems for Pulsed Power Applications,** Proceedings of the 5th IEEE Pulsed Power Conference, Arlington, Virginia, June 10-12, 1985, pp. 168-171 (May 1986).

Data-acquisition systems for pulsed power applications generally must provide nanosecond resolution, operate in an environment of high levels of electromagnetic interference, and acquire significant amounts of data simultaneously. To meet these demands, electrical systems have been used and optical systems are being introduced. Voluntary standards have been and are being developed which categorize the errors in the electrical measurement systems. Optical systems are in too early a state of development for similar standardization.
[Contact: Robert E. Hebner, (301) 975-2403]

Superconductors

Ekin, J.W., Moreland, J., and Brauch, J.C., **Electromechanical Properties of Superconductors for DOE Fusion Applications,** NBSIR 86-3044 (March 1986).

This is an interim report presenting data on superconductor performance under mechanical load, data needed for the selection of superconductors and the mechanical design of superconducting magnets for DOE fusion energy systems. A further aim of the reported research is to measure and understand the electromechanical properties of promising new superconductor materials with strong application potential at high magnetic fields. Results include the following. The first studies of strain vs. critical-current were made on a Chevrel-phase superconductor, $PbMo_6S_8$. Chevrel-phase superconductors were found to have a large strain effect, comparable in magnitude to that in A-15 superconductors like Nb_3Sn. Electromechanical-property measurements of an experimental liquid-tin-infiltrated Nb_3Sn conductor showed it to have an irreversible strain limit twice as large as that of bronze-process superconductors and a significantly higher overall critical-current density; the liquid-infiltration process thus has the potential for development of a practical Nb_3Sn conductor with both superior critical-current density and extremely good mechanical properties. Electromechanical parameters were obtained on several Nb_3Sn conductors that are candidate materials for superconducting fusion magnets, including conductors fabricated by the bronze, internal-tin, and jelly-roll processes. Thermal contraction data are reported on several new structural materials for superconductor sheathing and reinforcement, and a new diagnostic tool for probing the energy gap of practical superconductors has been developed using electron tunneling.
[Contact: John W. Ekin, (303) 497-5448]

Goldfarb, R.B., **Transient Losses in Superconductors,** NBSIR 86-3053 (June 1986).

Under steady-state conditions, there are no losses in superconducting wires. However, when subjected to alternating or transient magnetic fields or transport currents, losses in type-II super-

Superconductors, cont'd.

conductors can become significant. This report deals with hysteresis losses at 4 K measured by magnetization and complex magnetic susceptibility. The theoretical and experimental relationships between ac susceptibility and magnetization as functions of dc field were examined in terms of the critical-state model as developed by Carr and Clem. Minor-loop hysteresis loss is shown to be obtainable by direct measurement of loop area, from the imaginary component of ac susceptibility, and from the reversible susceptibility plus the critical current density or full-penetration field. Hysteresis and transport losses measured simultaneously in a Nb-Ti superconducting coil were found to agree substantially with the predictions of Minervini's two-dimensional model. Hysteresis loss measurements in a series of fine-filament Nb_3Sn superconductors showed that the effective filament diameter is a function of interfilament separation and local area ratio of matrix material to Nb. A review of internal fields in superconductors showed the importance of demagnetization factors and internal fields for the correct analysis of magnetic data. A theoretical method of calibrating ac susceptometers for cylindrical specimens, which is based on a mutual-inductance calculation, was developed.
[Contact: Ronald B. Goldfarb, (303) 497-3650]

Magnetic Materials and Measurements

Goldfarb, R.B., Rao, K.V., and Chen, H.S., **New Magnetic Phase Diagram of the Amorphous Pd-Fe-Si Ferroglass Alloy System**, Journal of Magnetism and Magnetic Materials, Vol. 54-57, pp. 111-112 (1986).

The magnetic phase diagram of amorphous $Pd_{80-x}Fe_xSi_{20}$ was examined. The peak in the imaginary component of ac susceptibility was used to determine the ferromagnetic-like/spin-glass transition temperatures Tfg. It was found that the T_{fg} line is highly field dependent and rises with increasing iron concentration.
[Contact: Ronald B. Goldfarb, (303) 497-3650]

Other Electrical Systems Topics

Hebner, R.E., Stenbakken, G.N., and Hillhouse, D.L., **Report of Tests on Joseph Newman's Device**, NBSIR 86-3405 (June 1986).

This report describes electrical measurements performed by the National Bureau of Standards on Joseph Newman's device. The tests were conducted between March and June 1986 at the request of the U.S. Patent and Trademark Office in accordance with several court orders. As a Federal science and engineering research laboratory that specializes in measurements and is responsible for maintaining U.S. standards for electricity, NBS has extensive experience and facilities for measuring the performance of electrical equipment.

The purpose of the measurements was to test the inventor's claim that the output power from the device was greater than the power which was supplied to the device from a battery pack. NBS was not requested to examine the theory behind the operation of the device.

The tests consisted of electrical measurements of the power drawn from the battery pack by the device (input power) and separate as well as simultaneous measurements of the output power. These measurements were done with several different sets of conventional, well-documented test instruments. Due to the specialized nature of the equipment, however, the instrumentation would not generally be found in most research laboratories. The electrical characteristics of the device, especially the sharp spikes in input and output waveforms, necessitated a variety of extensive and careful measurements and experimental checks to ensure that valid data resulted. Equipment selection was critical.

Other Electrical Systems Topics, cont'd.

The device's efficiency -- defined as the ratio of output power to input power -- varied depending on the voltage, load on the device, and the degree of degradation of the tape on the commutator of the device. If the device simply transferred the power from the batteries to the load, its efficiency would be 100%; in no case did the device's efficiency approach 100%.

At all conditions tested, the input power exceeded the output power. That is, the device did not deliver more energy than it used.
[Contact: Robert E. Hebner, (301) 975-2403]

ELECTROMAGNETIC INTERFERENCE

Radiated Electromagnetic Interference

FitzGerrell, R.G., **Linear Gain-Standard Antennas Below 1000 MHz,** NBS Technical Note 1098 (May 1986).

Gain and antenna parameters related to input impedance are calculated using a computer program named HVD6. This program uses well-documented equations to compute these parameters for gain-standard antennas used in relative-gain or gain-transfer measurements at frequencies below 1000 MHz. The utility of this program is that it calculates gain patterns and input impedances for linear dipoles above perfect or imperfectly conducting plane ground and in free space, and for monopoles on perfectly conducting plane ground. Examples are included to illustrate the use of the program. Uncertainties in the calculated parameters are estimated to be less than those of the measured parameters.
[Contact: Richard G. FitzGerrell, (303) 497-3737]

FitzGerrell, R.G., **Site Attenuation,** IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-28, No. 1, pp. 38-40 (February 1986). [Note: NBS Technical Note 1089 (November 1985) presents similar material and includes a derivation of the expression for site attenuation, an appendix describing the dipole antennas and an analysis of their mismatch loss and input impedance, and an appendix incorporating listings of the two FORTRAN 4 codes used.]

Site attenuation is a measure of performance of an open test site at frequencies below about 1 GHz. These sites typically consist of a large obstruction-free ground plane and the hemispheric volume above it. Calculations of site attenuation are presented which provide a reference for measurements made on a 30- by 60-m wire-mesh ground screen. Measured data are compared to the calculated results.
[Contact: Richard G. FitzGerrell, (303) 497-3737]

Friday, D.S., and Adams, J.W., **A Statistical Characterization of Electroexplosive Devices Relevant to Electromagnetic Compatibility Assessment,** NBS Technical Note 1094 (May 1986).

Electroexplosive devices (EEDs) are electrically fired explosive initiators used in a wide variety of applications. The nature of most of these applications requires that the devices function with near certainty when required and remain inactive otherwise. Recent concern with pulsed electromagnetic interference and nuclear electromagnetic pulse made apparent the lack of methodology for assessing EED vulnerability. A new and vigorous approach for characterizing EED firing levels is developed in the context of statistical linear models and is demonstrated in this paper. We combine statistical theory and methodology with thermodynamic modeling to determine the probability that an EED, of a particular type, fires when excited by a pulse of a given width and amplitude. The results can be applied to any type of EED for which the hot-wire explosive binder does not melt below the firing temperature.

Radiated EMI, cont'd.

Included are methods for assessing model validity and for obtaining probability plots, called "Firing Likelihood Plots". A method of measuring the thermal time constant of an EED is given. This parameter is necessary to evaluate the effect of a train of pulses. These statistical methods are both more general and more efficient than previous methods for EED assessment. The results provide information which is crucial for evaluating the effects of currents induced by impulsive electromagnetic fields of short duration relative to the thermal time constant of the EEDs.
[Contact: Dennis S. Friday, (303) 497-5395]

Hill, D.A., **A Numerical Method for Near-Field Array Synthesis,** IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-27, No. 4, pp. 201-211 (November 1985).

A numerical method for near-field array synthesis is developed for arbitrary array geometries. The intended application is for generating a planar field in a test volume for electromagnetic susceptibility testing, but the method is valid for arbitrary field distributions. A uniqueness theorem is utilized to allow the field conditions to be enforced on the surface of the test volume rather than throughout the volume. The synthesis method is a least-squares solution with a constraint on the source norm; the constraint keeps the field small outside the test volume. Numerical results are shown for the case of synthesizing a plane wave in the near field of an array of line sources.
[Contact: David A. Hill, (303) 497-3472]

Jesch, R.L., **Susceptibility of Emergency Vehicle Sirens to External Radiated Electromagnetic Fields,** National Institute of Justice Report-200-85 (May 1986).

Jesch, R.L., **Susceptibility of Emergency Vehicle Sirens to External Radiated Electromagnetic Fields,** National Institute of Justice Report-200-85 (May 1986).

This report provides the results of an exploratory study to determine the susceptibility of electronic sirens to interference from typical communications equipment such as the transmitters and antennas likely to be operated in and around a law-enforcement vehicle.

Tests were performed using five specimen sirens and communications equipment operating at frequencies representing the frequency bands of 25 to 50, 150 to 174, 400 to 512, and 806 to 866 MHz. The sirens were mounted on top of a vehicle equipped with transmitters and roof-mounted antennas and subjected to levels of field strength generated by mobile transmitting equipment having output power levels up to 100 W. In addition, the siren controllers were subjected to various levels of field strength inside either a transverse electromagnetic (TEM) cell or an anechoic chamber to determine their susceptibility to known electromagnetic fields.
[Contact: Ramon L. Jesch, (303) 497-3496]

ADDITIONAL INFORMATION

Lists of Publications

Gibson, K.A., Page, J.M., and Miller, C.K.S., **A Bibliography of the NBS Electromagnetic Fields Division Publications,** NBSIR 85-3040 (February 1986).

This bibliography lists publications of the National Bureau of Standards' Electromagnetic Fields Division for the period from January 1984 through September 1985, with selected earlier publications from the Division's predecessor organizations.
[Contact: Kathryn A. Gibson, (303) 497-3132]

Lists of Publications, cont'd.

Kline, K.E., and DeWeese, M.E., **Metrology for Electromagnetic Technology: A Bibliography of NBS Publications,** NBSIR 86-3048 (June 1986).

This bibliography lists the publications of the personnel of the Electromagnetic Technology Division of NBS in the period from January 1970 through December 1985. A few earlier references that are directly related to the present work of the Division are included.
[Contact: Kathryn E. Kline, (303) 497-3678]

Palla, J.C., and Meiselman, B., **Electrical and Electronic Metrology: A Bibliography of NBS Electrosystems Division Publications, NBS List of Publications 94** (January 1987).

This bibliography covers publications of the Electrosystems Division, Center for Electronics and Electrical Engineering, NBS, and of its predecessor sections for the period January 1963 to January 1987. A brief description of the Division's technical program is given in the introduction.
[Contact: Jenny C. Palla, (301) 975-2220]

Walters, E.J., **Semiconductor Measurement Technology: A Bibliography of NBS Publications for the Years 1962-1986,** NBSIR 87-3522 (February 1987).

This bibliography contains reports of work performed at the National Bureau of Standards in the field of Semiconductor Measurement Technology in the period from 1962 through December 1986. An index by topic area and a list of authors are provided.
[Contact: E. Jane Walters, (301) 975-2050]

1987 CEEE CALENDAR

July 28-30 (Vail, CO)

Short Course on Optical Fiber Measurements. This course is sponsored by the National Bureau of Standards and the University of Colorado with the cooperation of members of industry who serve as faculty together with staff from the Electromagnetic Technology and Electromagnetic fields Divisions. The course is intended for scientists and engineers involved in optical fiber characterization and emphasizes concepts, techniques, and apparatus used in measuring engineering parameters of telecommunications-grade fibers.

The following major topic areas are addressed: optics for communications, emphasizing geometric optics concepts; fiber properties and parameters; index-profile measurements; fiber bandwidth measurements in the frequency and time domains; fiber attenuation measurements; connector and splice losses; optical time-domain reflectometry concepts and applications; single-mode fibers; statistics and error analyses, measurement uncertainties; and fibers for sensors.
[Contact: Office of Conference Services, University of Colorado (303) 492-8630; Robert L. Gallawa (303) 497-3761; or Matt Young (303) 497-3223]

September 14-16 (Research Triangle Park, NC)

VLSI and GaAs Packaging Workshop. This Workshop is co-sponsored by the Components, Hybrids, and Manufacturing Technology Society of IEEE and NBS; attendees are expected to be knowledgeable in the field and to participate in discussions. Topic areas include: VLSI and wafer scale package design (characterization and implementation, cost and performance driven solutions); package thermal design (characteristics, results, and issues); package interconnection options (wire bonding, TAB, flip nection options (wire bonding, TAB, flip chip, or optical); GaAs IC packaging (high speed packaging considerations); package electrical issues (reduction of parasitics and improvements in electrical performances); integrating package design (from die to system, including

1987 CEEE Calendar, cont'd.

assembly and test issues); VLSI package materials advancements; die-attach solutions for large chips; new failure mechanisms in VLSI packaging. [Contact: George G. Harman, (301) 975-2097]

September 22-25 (Boulder, CO)

Noise Measurement Seminar. This four-day course is presented and hosted by the Electromagnetic Fields Division in cooperation with representatives from industry and the NBS Time and Frequency Division. It is intended for practicing noise metrologists and technical managers responsible for systems in which accurate measurements of thermal and phase noise are important. Attendees will learn the most important precautions to take in making accurate noise measurements and will receive a set of notes that are suitable for use in solving precision noise measurement problems. Course topics include reference thermal noise sources; thermal noise measuring systems and techniques; phase noise; and the problems of measuring thermal noise in passive components, amplifiers, and communication systems.

The course design combines formal lectures on theory presented by NBS staff and industry experts with demonstrations in NBS laboratories and demonstrations of commercial equipment. A special feature of the Seminar is the opportunity each day for attendees to share their experiences in solving specific problems or their insights on practical noise measurement issues through short presentations to the assembled group. Time is scheduled for group discussions of these presentations and other topics raised by the Seminar. [Contact: Sunchana Perera (303) 497- 3546]

September 23-25 (Gaithersburg, MD)

Workshop on the Role of Optics in Power System Electrical Measurements. This Workshop is sponsored by NBS, the Bonneville Power Administration (BPA), the Electric Power Research Institute (EPRI), and the Empire State Electric Energy Research Corporation (ESEERC) and is intended for research and development engineers in utilities and in companies that supply equipment to the utility industry. The objective of this workshop is to identify anticipated opportunities for improved measurement techniques that should arise as power systems individually and collectively evolve to meet the needs of the 1990s. Presentations will stress the design and testing of optical systems for 60-Hz voltage or current measurement; the interfacing of electronic or optical components with existing metering and control systems; opportunities for new measurement hardware resulting from increased automated control of power systems and of the testing of power system components; and optical techniques for the measurement of electric and magnetic fields in power systems or system components. The results of an NBS study evaluating optical techniques for power-system electrical measurements and carried out in agreement with BPA, EPRI, and ESEERC will be presented as an invited keynote. [Contact: Robert E. Hebner, (301) 975-2403]

October 26-28 (Boulder, CO)

Symposium on Optical Materials for High Power Lasers (Nineteenth Boulder Damage Symposium). This Symposium is cosponsored by the National Bureau of Standards, the American Society for Testing and Materials, the Air Force Office of Scientific Research, the Office of Naval Research, and the Defense Advanced Research Projects Agency and constitutes a principal forum for the exchange of information on the physics and technology of materials for high-power lasers.

Topics to be discussed include new materials, bulk damage phenomena, surface and thin-film damage, design considerations for high-power systems, and fundamental mechanisms of laser-induced

1987 CEEE Calendar, cont'd.

damage. Proceedings of the Symposium will be published (Note: The collection of Symposium proceedings contains information on optics for all aspects of high-power/high-energy lasers, including environmental degradation, durability, fabrication, material growth and deposition processes, and testing). [Contact: Susie A. Rivera (303) 497-5342]

December 10-11 (Gaithersburg, MD)

Power Semiconductor Devices Workshop. This Workshop, sponsored jointly by IEEE and NBS, is intended to bring together for interactive participation those actively working in the field of power semiconductor devices. It will be held in conjunction with the 1987 IEEE International Electron Devices Meeting in Washington, DC. Four specific topic areas have been selected, based on the response to a questionnaire sent to over 200 power device researchers worldwide. They are: power and high voltage integrated circuits, discrete devices, device modeling, and packaging. Attendees are expected to be prepared to contribute to the development of responses to specific questions that arise in the context of the particular topic areas; a final schedule identifying the topic areas should be available at the end of October. [Contact: David L. Blackburn, (301) 975-2053]

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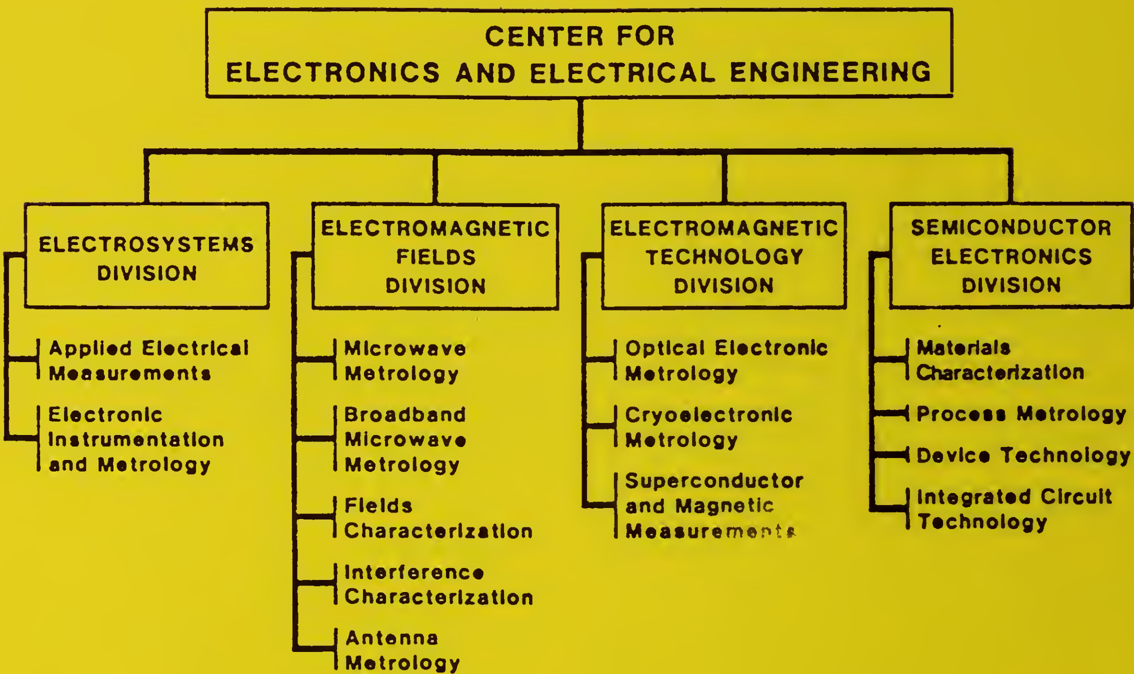

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