विद्युत तथा इलेक्ट्रॉनिक मानक

ELECTRICAL AND ELECTRONIC STANDARDS
विद्युत तथा इलेक्ट्रॉनिक मानक

विद्युत तथा इलेक्ट्रॉनिक मानक प्रभाग डी सी वोल्टटा, धारा तथा प्रतिरोध, ए सी वोल्टटा, धारा तथा प्रतिबाद, ए सी पॉवर तथा ऊर्जा, ए सी उच्च धारा तथा उच्च वोल्टटा, एल एफ तथा एच एएफ वोल्टटा, धारा, पॉवर तथा प्रतिबाद (लम्प्ड पैरामीटर्स), एल एफ श्रीणन (अट्टुएशन), सूक्ष्मतरंग शक्ति, श्रीणन प्रतिबाद तथा शोर, समय तथा आवृत्ति, चुनौतीय प्रेरण के प्राथमिक और राष्ट्रीय मानकों की प्रतिष्ठा, अनुसंधान और उद्योग (अप्रोड) करने में जुटा हुआ है। अनुसंधान और विकास सम्बन्धी गतिविधियां (आर एएस और एटीवीटीसी) जैसे मानकों, यथार्थी मूल्यांक, स्वीकार, जीव विकास का यंत्र आदि के विकास के लिए भी कार्य किया जाता है। यह प्रभाग अंशांकन और प्रणालियों द्वारा भी विभिन्न अंशांकन प्रयोगशालाओं और उद्योगों को प्रदान करता है।

इस संस्करण के दौरान इस मानक प्रभाग ने दो बार आई पी एम/ सी सी ई एम मुख्य अन्तर्भूतालों तथा एक ए पी एम वी अन्तर्भूता में अपनी सहभागिता दर्ज की। पिछले तीन सी ई एम मुख्य अन्तर्भूतालों के आंकड़े अंतर्राष्ट्रीय पहचान व्यवस्था (एम आर ए) के परिक्षेत्र 'ख' में शामिल किए गए हैं।
ELECTRICAL AND ELECTRONIC STANDARDS

The Electrical & Electronic Standards Division is engaged in establishment, maintenance and upgradation of primary/national standards of DC voltage, current and resistance; AC voltage, current and impedance; AC power and energy; AC high current and high voltage; LF & HF voltage, current, power and impedance (lumped parameters); HF attenuation; microwave power, attenuation, impedance and noise; time and frequency; and magnetic induction. R&D activities on development of standards, precision measurements, SQUIDs, bio-medical instrumentation are also carried out. Calibration and consultancy services are provided to various calibration laboratories and industries.

During the year the division participated in two BIPM/CCEM key comparisons and one APMP key comparison. The data of earlier three CCEM key comparisons have been approved for provisional equivalence for inclusion in the Appendix B of the global Mutual Recognition Arrangement (MRA).
Josephson Voltage Standard and Superconducting Devices

Josephson Voltage Standard

Josephson series array voltage standard has been maintained at 1 volt level. The "National Standard" of volt which is based on Zener diode has been calibrated against the Josephson voltage. R&D work has been initiated to develop 10 volt Josephson voltage standard.

High-Tc SQUID Based NDT Set Up

A high-Tc SQUID based computer controlled non-destructive testing (NDT) set up is developed. BSCCO high-Tc rf-SQUID is used in this setup. Figure 2.1 shows photograph of the SQUID-NDT setup. The SQUID remains at liquid nitrogen temperature whereas the specimen under inspection is kept on a computer controlled X-Y stage. Movement of X-Y stage is achieved through two stepper motors. An area of 10cm x 10cm can be scanned in this setup with the positional accuracy of 100 μm. A computer program for X-Y stage control and graphical display of NDT results is developed. A low frequency ac field (~10-20 Hz) is applied on the specimen and the observation is recorded for each position during scanning. Presence of defect/slot in the specimen distorts the magnetic field distribution which is detected by the SQUID.

Rf-SQUID Effect in Quaternary Borocarbide Superconductors

We had earlier reported rf-SQUID effect in YNi2B2C and in two magnetic borocarbide superconductors (DyNi2B2C, ErNi2B2C) which indicated that natural grain boundary in these three borocarbide superconductors behave as Josephson junctions. In order to check the universality of the nature of the grain boundaries in quaternary borocarbide superconductors, rf-SQUID effect is also studied in LuNi2B2C (Tc = 16.5 K) and YPd2B2C (Tc = 23 K). RF-SQUID voltage-flux modulations in both the superconductors are observed from 4.2 K to near superconducting transition temperature confirming that natural grain boundaries in these two superconductors also behave as Josephson Junctions. Thus it establishes that natural grain boundaries in all the borocarbide superconductors behave as Josephson weaklink.

Study of Destabilization of Charge Ordering in Pr-Ca-Mn-O Single Crystal Using High-Tc SQUID

Pr0.63Ca0.37MnO3 single crystal shows charge ordered (CO) insulating state at lower temperature. This charge ordered state can be destabilized by the application of an electric field beyond a threshold value. I-V characteristic of the crystal shows non linearity after a threshold value of voltage which is due to destabilization of charge ordered state. A High-Tc BSCCO rf-SQUID is used for checking the appearance of magnetic signature due to destabilization of charge ordered state. The Pr0.63Ca0.37MnO3 single crystal is placed just above the SQUID and the experiment is performed at 77K. I-V characteristics of the charge ordered single crystal is measured and simultaneously magnetization of the crystal is also measured using High-Tc SQUID. Figure 2.2 shows plot of the SQUID output and voltage across the crystal at 77K as a function of biasing current. It clearly shows that the current induced destabilization of charge ordered state leads to a small enhancement of the magnetization of the sample, indicating ferromagnetically aligned moment. This suggests that destabilization of CO state suppresses AFM spin correlation and promotes FM spin correlation.
Study of Conduction Noise in Polycrystalline CMR Films

Temperature and frequency dependence of conduction noise in screen printed La$_{0.67}$Ca$_{0.33}$MnO$_3$ polycrystalline film is studied. The film has a metal-insulator transition temperature ($T_p$) and ferromagnetic transition temperature ($T_c$) at 140 K and 230 K, respectively. The magnetoresistance ratio (MR) of the film at 1kOe is found to be mainly due to grain boundaries. The observed voltage noise spectral density ($S_v$) shows $1/f$ type behaviour for all the temperatures ranging from 77 K to 300 K. $S_v$ shows an increase as the temperature is decreased below $T_c$ and reaches a peak value at $T_p$. The increase in $S_v$ below $T_c$ is attributed to extra noise arising due to fluctuations in spin alignment in the ferromagnetic state. Application of a 1kOe magnetic field reduces noise and the reduction in the noise is observed up to $T_c$. A comparison of the temperature dependence of MR and noise reduction ratio due to magnetic field indicates that the magnetoresistance in the polycrystalline film of La$_{0.67}$Ca$_{0.33}$MnO$_3$ is strongly influenced by the grain boundaries but the noise due to fluctuations in spin alignment is intrinsic and comes mainly from the grains.

The properties of Ag added La$_{0.67}$Ca$_{0.33}$MnO$_3$ (Ag-LCMO) polycrystalline film are compared with those of the La$_{0.67}$Ca$_{0.33}$MnO$_3$ (LCMO) film prepared under similar conditions. The addition of silver in LCMO films improves surface morphology and reduces the lattice constant. During the synthesis process, the silver in the Ag-LCMO film melts and segregates at the grain boundaries. The semiconductor-metal transition temperature ($T_p$) increases by 10K. Normalized voltage noise reduces by more than one order of magnitude. Improvement in surface morphology and better oxygenation of the film due to the presence of silver leads to improvement in the properties of polycrystalline LCMO film.

Study of Magnetoresistance and Non-Linear Conductance of Bicrystal Grain Boundary in CMR Film

Epitaxial film of La$_{0.67}$Ba$_{0.33}$MnO$_3$ (LBMO) is prepared
on 36.7\textsuperscript{th} SrTiO\textsubscript{3} bi-crystal substrate using laser ablation technique. For studying the effect of the grain boundary on transport characteristics, two microbridges have been fabricated. One microbridge was created across the bicrystal grain boundary and the other one away from the bicrystal grain boundary. The grain boundary exhibits substantial magneto resistance at low temperatures (Figure 2.3) and also shows non-linear I-V characteristics.

Analysis of temperature dependence of the dynamic conductance allows us to identify three carrier transport mechanisms across the grain boundary. These mechanisms exist in parallel and at a given temperature one mechanism may dominate. Particularly at higher temperatures (T>170K) the transport across the grain boundary involves spin flip scattering, which we establish leads to decrease of grain boundary contribution in magneto resistance. At lower temperature (4.2K-45K) tunneling through a disordered oxide at the grain boundary is dominating whereas in the temperature range from 100K to 170K carrier transport is dominated by inelastic tunneling via pairs of manganese atoms.

**DC Standards**

DC Standard maintains national standard of DC voltage, current and resistance and provides apex level calibration to various laboratories and industries. The group has participated in BIPM key comparison, CCEM-K8 programme for voltage ratios. IEN, Italy acted as coordinating laboratory for the programme. The participating laboratories were: Australia, New Zealand, Canada, China, France, India, Japan, Korea, Russia, Spain, South Africa, Sweden, UK, and USA. During the year an automated precision multifunction calibrator facility has been established for providing high precision calibration facilities to various governmental, industrial and other users.

![Graph showing temperature dependence of magneto resistance (MR) of LBMO thin film microbridges across bicrystal grain boundary and away from the grain boundary. Magneto resistance has been calculated using the relation: MR=\{[R(H)-R(0)]/ R(0)]\}x 100%, where R(H) and R(0) are resistance of the microbridge in presence and in the absence of magnetic field, respectively.](image-url)
**DC High Voltage Standard**

A new measurement and calibration facility for DC high voltage up to 100kV has been established. This will help our TV & X-ray industries and also various calibration laboratories in the field of HV calibration. Initially, it is planned to calibrate the equipments upto 100kV including HV probes, Electrostatic voltmeters, dividers and Power supplies, with an accuracy of 0.02%.

**AC Power & Energy Standards**

The AC Power & Energy Standard section is

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**Fig. 2.4**: The experimental set-up of DC high voltage measurement facility

**Fig. 2.5**: Close-up of 100kV divider
providing testing and calibration facility for single phase and three phase AC power meters, power analyzers, power factor meters and single phase and three phase AC electromechanical energy meters, static energy meters for active, reactive and apparent energies at power frequencies. The test and calibration facility is widely used by all power utilities, electricity boards, meter manufacturers and other test and calibration laboratories.

Several coils were developed to create AC axial magnetic induction of varying strength at the center of a circular 320 mm internal diameter coil and its influence on the performance of a number of static energy meters were studied. The test was conducted by keeping the coil in various orientations. The test was included in CBIP report as amendment "Test of influence of alternating (a.c.) abnormal magnetic induction of 10 milli tesla produced at the center of a circular coil of 320mm internal diameter."

By installation of a 3 phase reference standard COM 303, the uncertainty of measurement has been improved from ± 0.02% to ± 0.01% with respect to apparent power.

**AC High Current & High Voltage Standards**

This section is maintaining National Standards of AC high current and high voltage at power frequencies (50 Hz). Calibration services was provided for Current Transformers, CTTS, Clamp Meters, AC Current Shunts, Weld Testers, CTTS Jigs, CT Burdens and for Potential Transformers, PTTS, H.V. Probe, Electrostatic Volt Meters (ESVM), HV Breakdown Test Sets, and PT Burdens etc. As many as 75 calibration certificates were issued to the electrical manufacturers and utilities.

Work has been initiated on the development of a laboratory grade current transformer which will ultimately lead to the establishment of absolute method for the calibration of current transformers. It is planned to push up the calibration facilities for the calibration of current transformers to a better accuracy from ± 0.005% to ± 0.001%.

**LF and HF Impedance Standards**

This section is maintaining primary standards of capacitance which is Calculable Cross Capacitance based on Lampard-Thompson theorem. The unit of inductance, Henry, is realized from capacitance using Maxwell-Wien Bridge. The unit of resistance, Ohm, is also realized from capacitance using Quadrature Bridge (Fig. 2.6) and other precision ac bridges. This section also provides apex level calibration for the

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![Quadrature Bridge for Realisation of 'Ohm' through 'Farad'](image)
above parameters at low and high frequencies, to
various calibration laboratories and R & D
organizations.

The setup for absolute calibration of Inductive
Voltage Divider (IVD) was modified, re-established
and evaluated to assign the value to standard IVDs. At
present, an uncertainty of few parts in $10^6$ is achieved
in comparison to previously achieved uncertainty of
5 parts in $10^6$.

International inter-comparison of AC voltage
ratio under CCEM key comparison has been
completed. In this inter-comparison, 15 laboratories
like NIST USA, PTB Germany, NPL UK, NML
Australia etc. are participating.

One scientist from CSIR-NML, South Africa
visited for 5 weeks to get training on Quadrature
Bridge. He also brought one 10 pF capacitor for
calibration against our national standard of
capacitance.

Proficiency Testing Programme for NABL
accredited laboratories in measurement of ac
resistance and capacitance has been initiated in
collaboration with NABL. In this programme 6 and 13
calibration laboratories of India are participating for ac
resistance and capacitance, respectively.

**LF, HF and MW Standards**

This section carried out BIPM comparison CCE 92-03
on AC/DC voltage transfer standards at the lowest
level of uncertainty in the frequency range 1 kHz to 1
MHz (declared as a key comparison CCEM-6.a) and
CCE 92-05 on AC/DC voltage transfer standards at
higher frequency range 1 MHz to 50 MHz - declared as
key comparison CCEM-K6.c by the BIPM
Consultative Committee on Electricity and Magnetism
(CCEM). In CCEM-K6.a twenty two standards
laboratories belonging to countries including
Germany, USA, India, UK, France Australia and the
Netherlands have taken part, whereas in CCEM-K6.c
the number of participating laboratories was only
fifteen. These included those of USA, UK, Germany,
the Netherlands, India, Australia and Canada etc.
Fig. 2.7 shows the set up used in CCEM-K6.a.

Our results have been included for the
determination of comparison reference value at all the
frequencies (both comparisons) in order to derive
equivalence among different countries. The criteria for
inclusion of results for determination of comparison
reference value was that the laboratory must have
independent realization of AC/DC transfer error for
their standards associated with small uncertainty and
having a sound uncertainty budget. In both these

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Fig.2.7: Set up for Low Frequency Voltage Comparison (CCEM K6.a)
Fig. 2.8: Degree of equivalence for different NMIs with respect to comparison reference value at 1 MHz (CCEM-K6.a)

comparisons the values of AC/DC transfer error assigned to the respective travelling standards by our laboratory have very close agreement with the comparison reference values at all the frequencies. Fig. 2.8 shows degree of equivalence of standards of different countries with respect to reference value at 1 MHz (CCEM-K6.a). It clearly shows that our value is very close to the comparison reference value. CCEM has recommended the results to be included in appendix B of BIPM data base.

A number of standards and precision instruments of various user organizations have been calibrated. 51 calibration certificates have been issued during this year.

**HF & Microwave Attenuation and Impedance Standards**

The spot frequency calibration facilities in attenuation and impedance parameters established at 30 MHz & 1 to 18 GHz in 50 Ω coaxial system and 3.95 to 18 GHz in waveguide system are being used by various user organisations. The calibration facilities have also been extended up to K-band (18 - 26.5 GHz) in the waveguide system. A set of coaxial transfer standards of VSWR 1.10, 1.30 & 1.50 has been designed and developed in the frequency range 2-18 GHz by modifying the existing HP-905A sliding load. The facilities for measurement of attenuation and impedance in terms of scattering parameters have been established using vector network analyzer (VNA) based system in the frequency range 40 MHz to 20 GHz. The experimental set-up for the measurement of s-parameters using Wiltron-37247B VNA is shown in Fig. 2.9.

**Magnetic Standards**

**DC Measurements on Soft Magnetic Materials**

Facility has been established for the DC measurement on soft magnetic materials using standard permeameter as per IEC standard. The DC measuring system consists of permeameter, precision DC power supply, data acquisition and parameter control unit. The system is fully automated. The samples used are in the shape of rods and bars. The parameters measured
are field strength, coercivity, remanent induction etc. The measurement range is:

- Coercivity: $\sim 100$ A/m to 1 kA/m
- Remanent induction: 0.5T to 1.5T
- Field strength: $10^2$ A/m to $10^3$ A/m

The setup is shown in the Figure 2.10.

**Bilateral International Inter-comparison in the Area of DC Magnetic Measurements**

Bilateral international intercomparison on soft magnetic materials with PTB, Germany as per IEC Standard 60404-4 has been done. Measurements were conducted on two steel samples in the shape of rods both at NPL and PTB, Germany. The results obtained
are given in Table-1.

### Table-1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sample No. 1</th>
<th>Sample No. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PTB</td>
<td>NPL(I)</td>
</tr>
<tr>
<td>(H_p)</td>
<td>0.726 kA/m</td>
<td>0.762 kA/m</td>
</tr>
<tr>
<td>(H_q)</td>
<td>0.7278 kA/m</td>
<td>0.763 kA/m</td>
</tr>
<tr>
<td>(B_r)</td>
<td>1.480 T</td>
<td>1.480 T</td>
</tr>
</tbody>
</table>

**Calibration of Reference Gaussmeter and Reference Magnets Against National Standards**

Calibration of reference Gaussmeter and reference magnets have been done against NMR Gaussmeter (National Standard). Detailed calculations for determining the measurement uncertainties have been carried out.

**Time and Frequency Standards**

A Project on the "Studies on the Potentiality of GLONASS (Global Navigation Satellite System) for the Positioning and Timing vis-à-vis applications of GPS (Global Positioning System)" was completed. The Report of this project has been published in the form of a book. The report elaborates the observations for effective utilisation of GPS and GLONASS constellation and serves as a reference document for users of GPS and GLONASS. The work on a New PLL (Phased Locked Loop) which increases locking range as well as improves the noise immunity to discipline the Frequency Standard has been completed in collaboration with PTB Germany.

A new technique to improve the accuracy of GPS timing has been developed. BIPM has taken keen interest to consider this technique to improve the accuracy of on-line GPS time through the geodetic GPS receiver.

Digital time service via telephone line has already been started by most of the developed countries but these services can only be accessed by computers only. But NPL has started similar service recently with some unique feature in the name of TELE CLOCK Service. NPL time service via telephone can not only be accessed by a computer but also by an innovative receiving system. Clocks of Lok Sabha are now synchronised to IST through Tele clock service. This system to access digital time service from NPL has been granted US Patent.

Three major projects were carried out to design and develop INSAT STFS receiving systems for the NTPC, Dadri, Gujarat Electricity Board (GEB), Vadodara and MP State Electricity Board (MPSEB), Jabalpur. These systems have specific interfaces that are used to accurately synchronise the timing of the event logging process at these sites to IST. With STFS based synchronisation at GEB and MPSEB, the entire western grid is synchronised to IST. This greatly helps identification of grid disturbances. All these systems were installed and commissioned and are fully operational.

As a part of the Project sponsored by BRNS, Dept of Atomic Energy, long term differential STFS data were collected at NPL; ERTL(E), Calcutta; BARC, Trombay and BARC, Mt Abu in Sept - Dec 1999 and analyzed. Numerical simulations were carried out on the multi-station data resulting in high degree of improvement in the satellite orbital parameters and hence the time transfer accuracy.

Under the Indo-US project on precision Frequency Metrology, work was continued on design and development of a microwave synthesiser for laser cooled Cs fountain standard. A newer version of the Cs synthesiser was designed in collaboration with NIST, Boulder, USA for use with the proposed PARCS (Primary Reference Clock in Space) to be flown on board the Space shuttle in Dec 2004. This work was
carried out at NIST. The Cs synthesiser has the best reported performance in terms of its internal stability. Ten units of the synthesiser have been developed - to be used by several major time standards laboratories in their Cs fountain standards work. One of the units is for NPL, India for our proposed Cs fountain.

Several electronic circuits such as temperature controller, laser diode current controller, photodiode monitor and the servo controller were designed and developed to achieve the stabilisation and subsequent frequency locking to a Cs hyperfine line using a Cs vapour cell. An 852 nm diode laser has been successfully locked to hyperfine lines of Cs.

**Bio-Medical Measurements and Standards**

Basic research has been carried out on the characterisation of biological tissues for ultrasonic and electrical properties, to enable develop 'safety standards' for avoiding side effects on the surrounding tissues. The human teeth and tumours have been studied in detail. It has been further investigated that cavitation bubble formation is enhanced by external stimulation to increase the efficiency of the stone disintegration in lithotripters.

**Leiomyoma Uteri:** Ultrasonic characteristics of these uterine tumours, in vitro, have been studied, by using a double-probe through-transmission technique. The average acoustic velocity and attenuation are found to be 1550 m/s and 433 dB/sq m, respectively, at 3.5 MHz frequency and room temperature 28°C. The present investigation is useful in tissue differentiation to enable the doctors to give proper treatment.

**Bone Cystic Lesion:** Ultrasonic and physical properties of bone cyst, a non-neoplastic tumour, have been studied, in vitro. Average ultrasonic propagation velocity and attenuation are found to be in the range 1602 to 1669 m/s and 1846 to 2181 dB/m, respectively. The main causes of the variation of these parameters are porosity and complex nature of the samples used. The data is used as an index of identification of diseases, after proper standardisation.

**Human Teeth:** The human teeth, collected from different hospitals, have been studied for dielectric, physical and ultrasonic properties. Porosity and XRD studies are made for comparative study for the chemical constituents. The investigation is useful to the doctors to develop dentures and other dental materials. The effect of ultrasound intensity on the tissue structure, particularly thermal behaviour, has been studied in detail.

**Electro-medical Standards:** Current status and the need of biomedical standards among the users /hospitals and manufacturers of biomedical equipment in India and abroad were explored. A brainstorming meeting of one day on biomedical standards was organised at NPL in collaboration with industries, hospitals and other agencies. Biometry calibration set up was developed and established for monitoring the resolution and sensitivity of biometry probes/transducers, by using trajectory control system in X, Y, Z and directions. A special sensor has been designed to study and monitor the intensity output of high power transducers. The studies in biological tissues (human teeth, tumours and biomaterials), ancient preservative materials, were continued. A special thermal profile monitoring system was developed to study the temperature elevation in the deep seated tumours in the brain or other parts of the body.

**Lithotripsy Research:** Shock Wave Lithotripter was studied for its working parameters like excitation voltage, resonance frequency, bandwidth, and output energy. It was found that an acoustic transducer with 40 to 60 kHz, with several watts of power can be used, for external stimulation. A special VFFVAT (variable-frequency-variable-amplitude transducer) was used for acoustic stimulation. It was found that with the increase of the frequency and power of the stimulating transducer, the size and the number of cavitation bubbles are found to be enhanced.
इंजीनियरी पदार्थ

इंजीनियरी पदार्थ प्रभाग में तीन ग्रुप समाविष्ट हैं अर्थात धातुएं तथा मिश्र धातुएं, उन्नत कार्बन उत्पाद तथा उच्च दाब प्रौद्योगिकी ग्रुप। यह प्रभाग मुख्यतया पदार्थों के प्रौद्योगिकी विकास, सामरिक महत्व के घटक और प्रक्रियाएं, उच्च निर्माण तथा सामान्य इंजीनियरी अनुप्रयोगों से संबंध हैं। वर्ष के दौरान अधिकांश विकासात्मक परियोजनाओं को प्रयोक्ता संगठनों/ एजेंसियों जैसे - हिन्दुस्तान एयररोनॉटिक्स लिमिटेड, बंगलौर, विक्रम सारामाई स्पेस सेंटर, मुम्बई, इंस्टीट्यूट फॉर प्लाज्मा रिसर्च, गांधी नगर, इंडियन ऑयल कारपोरेेशन, फरीदाबाद के लिए हाथ में लिया गया है। आजकल कुछ अन्तर्राष्ट्रीय एजेंसियों के साथ मिलकर उनके संयुक्त प्रयास से की जाने वाली परियोजनाएं भी कार्य अधीन हैं।