विद्युत तथा इलेक्ट्रॉनिक मानक

ELECTRICAL & ELECTRONIC STANDARDS
विद्युत तथा इलेक्ट्रॉनिक मानक

विद्युत और इलेक्ट्रॉनिक मानक डिवीजन निम्नलिखित कार्यों में लगी हुई है – समय और धारा की एस आई यूनिटों का प्रयोग (रीआलाइजेशन) करने, विद्युत, इलेक्ट्रॉनिक और चुम्बकीय मानदंडों जैसे समय तथा आवृति के मुख्य राष्ट्रीय मानकों के विकास और अनुरक्षण में जोड़कर वाल्टेज, डी सी वोल्टेज, धारा और प्रतिरोध, ए सी पावर ऊर्जा, ए सी उच्च धारा और उच्च वोल्टेज, ए सी वोल्टेज, धारा प्रतिरोध एल एफ तथा ए एफ प्रतिबाद, स्थायीयता पैरामीटर्स, एच एफ और सुक्ष्मतारंग शक्ति, संकोचन, प्रतिबाद, और शोर और चुम्बकीय तेल। यह डिवीजन ए पी एम पी और बी आई पी एम द्वारा आयोजित अन्तर्राष्ट्रीय अन्तर्रुलनाओं में भाग लेती है तथा द्विपक्षीय तुलनाओं (बाईलॉटरल इंटरकम्पेटेंशन्स) में भी भाग लेती है। ताकि अंतर्राष्ट्रीय अनुमान योजनाओं को स्थापित किया जा सके। यह शीर्ष स्तर का अंशानक सेवा और तकनीकी परामर्श सेवा उच्च मानदंडों में अन्य अंशानक प्रयोगशालाओं और उद्योगों को प्रदान करती है।
The Electrical and Electronic Standards Division is engaged in realization of SI Units of Time and Current, development and maintenance of primary/national standards of electrical, electronic and magnetic parameters such as time and frequency; Josephson voltage; DC voltage, current and resistance; AC power and energy; AC high current and high voltage; AC voltage, current, resistance; LF and HF impedance (lumped parameter); HF and Microwave power, attenuation, impedance and noise and magnetic field. The division participates in international intercomparisons organized by APMP and BIPM as well as bilateral comparisons to establish international traceability. It provides apex level calibration service and technical consultancy in the above parameters to other calibration laboratories and industries.
Time and Frequency Standards

A study has been undertaken to find the accuracy of GPS time for on-line applications. The time from GPS receivers has been found to be off by few microseconds in many situations. After the optimization of bias errors, the accuracy of the receiver was found to have improved.

During high solar activity period, it has been found that the accuracy of GPS time gets deteriorated when there is a strong scintillation. This effect on time cannot be cancelled even in common view mode.

Time service via telephone network (i.e. Teleclock Service) has been in operation. Some improvement in the transmitting units has been done to make the system more efficient operationally. To start similar service in SASO, Saudi Arabia, the necessary design and development of the equipment have been completed.

Standard Time & Frequency Signals (STFS) have been broadcast over the INSAT 2C parked at 93.5 Deg East. This broadcast with national coverage has been operational with 0% down time over the full year. Precise orbital elements were updated every fortnight for accurate time transfer using the differential technique. During the year the following new contract projects were carried out. The entire STFS receiving system was installed at Badarpur Thermal Power Station (BTPS), Badarpur. At National Thermal Power Corporation (NTPC), Dadri the existing STFS system was augmented by installing large Slave Clock units synchronized to the STFS. Work was initiated to design and develop a Differential STFS receiving system at the Agilent Technologies (Pvt) Ltd, Bangalore. This project is ongoing and the actual installation is yet to be made.

Progress made in the Laser Cooled Cs Fountain programme mainly consisted of establishing frequency stabilized 852 nm extended cavity diode laser systems. The lasers were frequency locked to Cs D2 line in a saturated absorption spectrometer. Necessary electronics for the temperature control, laser diode current supply and the servo circuits were developed.

Josephson Voltage Standards and Superconducting Devices

Josephson Voltage Standard

Josephson series array voltage standard has been maintained at 1 volt level. The “National Standard” of volt is being calibrated at regular interval of six months against the Josephson Voltage Standard (JVS). Calibrated Zener reference standard against JVS was used in CCEM-K8 intercomparison to provide traceability. R&D work is in progress to develop 10 volt Josephson series array voltage standard.

Process for Encapsulation of High-Tc SQUID Sensor

For a long term operational life of high-Tc SQUID, the characteristics of SQUID sensor should not deteriorate with thermal cycling. A process for encapsulation of the SQUID sensor in a copper cavity has been developed. The performance of encapsulated sensor has been tested over a long period. Figure 2.1 shows the values of peak to peak amplitude and the flux noise of the encapsulated SQUID as recorded at 77 K after several thermal cycling at different period of time upto 34 months. It is evident that no change in the SQUID characteristics has been noticed over a long period even after several thermal cycling from room temperature to liquid nitrogen temperature.

Setup for the Measurement of Magnetic Fluctuation in Doped Rare Earth Manganite using High-Tc SQUID

For measuring magnetic fluctuation in doped rare earth manganite, a setup is developed in which high-Tc rf-SQUID works as a magnetic sensor having a field sensitivity $= 5 \times 10^{-11} \, \text{T/\sqrt{Hz}}$ in the white noise region. In this setup, SQUID remains dipped in liquid nitrogen inside a tail type glass dewar and the sample is kept outside at the tip of the tail. The temperature of the
Fig. 2.1: SQUID voltage and flux noise of the encapsulated high-Tc SQUID sensor

Sample can be varied from room temperature to liquid nitrogen temperature. This setup is also being used for measuring temperature dependence of magnetic phase separation of doped rare earth manganites.

**Weak-link Grain-boundaries in MgB₂ Supreconductors**

In order to understand the nature of natural grain boundaries in MgB₂ superconductors, rf-SQUID studies have been carried out using a small piece of bulk MgB₂ superconductor. The MgB₂ sample was surrounded by eight-turn coil which formed a part of the inductance of the tank circuit of the rf-SQUID electronics. The resonance frequency and quality factor of the tank circuit was 18.3 MHz and 62 respectively. Periodic oscillation in the voltage-flux (V-Φ) oscillation was 3 mV at 4.2K. The amplitude of SQUID modulation was found to decrease with the increase of the operating temperature and it disappeared at T=35K. The observation of rf-SQUID effect in bulk MgB₂ superconductor indicates the presence of weak-link grain-boundaries in the bulk superconductors.
**Improvement in the Stability of $La_{0.67}Ca_{0.33}MnO_3$ Film due to Silver Addition**

Metal insulator transition temperature ($T_p$), resistance and magneto-resistance (MR) of $La_{0.67}Ca_{0.33}MnO_3$ (LCMO) polycrystalline film have been studied after each thermal cycling from room temperature to 77K. It has been found that values of $T_p$ and MR changes after couple of cycling. Resistance of the film increases and $T_p$ shifts to lower temperature after each thermal cycling. Silver added LCMO film is also prepared and similar studies have been carried out. Figure 2.2 shows values of $T_p$ for LCMO film and silver added LCMO film. The addition of silver has been found to improve stability of the film against thermal cycling. $T_p$ of silver added LCMO did not change even after several thermal cycling. The change in $T_p$ of polycrystalline LCMO film after thermal cycling is attributed to loss of oxygen from the grain boundary due to thermal stress.

**Conduction Noise of Bicrystal Grain-Boundary in Doped Rare Earth Manganite**

Behaviour of a single artificial grain boundary in $La_{0.67}Ba_{0.33}MnO_3$ (LBMO) epitaxial film is studied for understanding the role of grain boundaries in generating excess noise in polycrystalline doped rare earth manganite films. The artificial grain boundary is realized by depositing the film on a $36.7^\circ$ SrTiO$_3$ bicrystal substrate. Figure 2.3 shows normalized conduction noise ($S/N^2$) of the grain boundary and the epitaxial film. It is evident that the presence of grain boundary introduces more conduction noise which has been attributed to oxygen deficient layer at the grain boundary.

**DC Current, Voltage and Resistance Standards**

DC Standards maintains “National Standard” of dc voltage and resistance and provides apex level
calibration to various laboratories and industries. The group also participated in CCEM-K8 Key Comparison of DC Voltage Ratios, details given below.

**DC High Voltage Standards**

**Participation of NPL-India in CCEM-K8 Key Comparison of DC Voltage Ratios**

NPL India has participated in CCEM-K8 Key Comparison of DC voltage ratios 1000:10, 300:10, 100:10, 30:10 and 10:1. NMIs of fourteen countries participated in this Key comparison and IEN, Italy was the pilot laboratory.

The IEN, Italy was given the responsibility to start the international intercomparison (key comparison) on DC voltage ratios by Consultative Committee of Electricity and Magnetism (CCEM) in its 20th meeting in June 1995. The key comparison CCEM-K8 started in October 1998 and finished in June 2001, with fourteen participating National Metrology Institutes (NMIs) namely CSIR-South Africa, NIST U.S.A, LCIE France, SP Sweden, NPL U.K., CEM Spain, KRISS Korea, CSIRO-NIM Australia, NIM China, VNIIM Russia, NRC Canada, MSL New Zealand, NPL India (NPLI), NMIJ Japan.

As per the schedule of CCEM-K8 Key Comparison, one travelling standard (DC voltage divider Datron 4902S) was received in NPLI during March 2001. It has one hundred 10 kW resistive elements, each made up of two parallel 20 kW thick film resistors. Adjustment trimmers in the divider were sealed (not to be adjusted by participants) by the pilot laboratory.

The ratios 1000:10 and 100:10 were mandatory while other ratios were optional for the comparison. The mandatory ratios 1000:10, 100:10 and optional ratios 300:10, 30:10 were to be measured at the corresponding terminals while ratio 10:1 at 100 V/10 V terminal and ratio 10:0.1 at 1000 V/10 V terminal respectively. The standard ambient conditions of temperature (T) 23 ± 0.5 °C and relative humidity (H) 45 ± 5% were recommended for CCEM-K8 intercomparison. The goal of the comparison was to achieve a relative uncertainty (combined Type ‘A’ and Type’B’) of ± 0.5 ppm or less at k=1 for the ratios 1000:10 and 100:10.
We have carried out various measurements on different ratios using NPLI reference divider and travelling standard. The uncertainty of results were estimated using Type ‘A’ and Type ‘B’ methods and reported at k=1 for all the ratios.

At NPLI, measurements were done by comparison method against the reference divider maintained by NPLI. The schematic of measurement is shown in Fig.2.4. The circuit consists of a stable voltage source like a calibrator, a Zener voltage reference standard at 10V & 1.018V, a reference divider and a sensitive null detector. The reference divider was powered by a calibrator which was regulated to balance the 10V output of the divider against a calibrated Zener voltage reference standard, using a sensitive null detector. The calibrator was set at approximately the voltage of measurement and its voltage was adjusted to produce a null in the detector. The value at which the calibrator produces a null and the value of voltage of the Zener standard (10V or 1.018V) were divided to get the ratio of the reference divider. The measurements were then repeated after replacing the NPLI divider with travelling standard (divider) and recording all the measurement data. The measurements were performed during the period from March 30, 2001 to April 16, 2001.

The measurements were done in the laboratory which was having controlled conditions of temperature & humidity, the value of which are given below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>23 °C ± 1 °C</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>45% ± 10%</td>
</tr>
<tr>
<td>Atmospheric pressure</td>
<td>980.56 hPa ± 0.50 hPa</td>
</tr>
</tbody>
</table>

The pilot laboratory has reported the results of intercomparison as uncertainty budget in the form of tables as given in the draft ‘B’. NPLI results included the following sources of uncertainty (at k=1) as given below (Table 2.1):

**Degree of Equivalence**

One of the main aim of CCEM-K8 key comparison was to determine the degree of equivalence of the participating NMIs. The degrees of equivalence were evaluated following the Mutual Recognition

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Fig. 2.4 : The circuit diagram of the traveling standard (voltage divider 4902S) used for inter comparison. Also shown the electrical connections and instruments used
Arrangement of the CIPM. The key comparison reference value, $D_0$, of this comparison is the arithmetic mean of the differences, with respect to the pilot laboratory. The degrees of equivalence with respect to the reference value is given by $D_i = (D_j - D_0)$, where $D_j$ is the differences between laboratory $i$ and the pilot lab. The corresponding expanded uncertainty $U(D_i)$, assessed for a level of confidence of 95%. The plot of degree of equivalence for the ratios 100:10 and 1000:10 are given here as Fig.2.5 (a,b).

It implies that international intercomparisons are not only useful to determine the degree of equivalence but also to develop more precise methods of measurements. The degree of equivalence of NPL obtained in mandatory ratios 1000:10 and 100:10 is found to be within 1 ppm from the mean value.

### AC Power and Energy Standards

The AC Power & Energy Standards section is providing testing and calibration facility for single phase and three phase power and energy meter for active, reactive and apparent values to electricity boards, meter manufactures and other test and calibration laboratories.

To overcome the problem of tampering of the static energy meters from the influence of AC/DC

### Table 2.1 : Relative uncertainty budget for the ratio 1000:10 (at $k=1$)

<table>
<thead>
<tr>
<th>Source of Uncertainty</th>
<th>Estimate $x_i$ (ppm)</th>
<th>Standard uncertainty $u(x_i)$</th>
<th>Probability Distribution / method of evaluation</th>
<th>Sensitivity coefficient $c_i$</th>
<th>Uncertainty contribution $u_i(R)$ (ppm)</th>
<th>Degrees of freedom</th>
</tr>
</thead>
<tbody>
<tr>
<td>$u_1$ (divider)</td>
<td>0.2</td>
<td>0.12</td>
<td>Rectangular, B</td>
<td>1</td>
<td>0.12</td>
<td>$\infty$</td>
</tr>
<tr>
<td>$u_2$ (detector)</td>
<td>0.03</td>
<td>0.02</td>
<td>Rectangular, B</td>
<td>1</td>
<td>0.02</td>
<td>$\infty$</td>
</tr>
<tr>
<td>$u_3$ (source stability)</td>
<td>0.7</td>
<td>0.27</td>
<td>Normal, B</td>
<td>1</td>
<td>0.27</td>
<td>$\infty$</td>
</tr>
<tr>
<td>$u_4$ (Zener stability)</td>
<td>0.1</td>
<td>0.06</td>
<td>Rectangular, B</td>
<td>1</td>
<td>0.06</td>
<td>$\infty$</td>
</tr>
<tr>
<td>$u_5$ (repeat-ability)</td>
<td>$u(\xi)$</td>
<td>0.19</td>
<td>Normal, A</td>
<td>1</td>
<td>0.19</td>
<td>6</td>
</tr>
</tbody>
</table>

$R_{1000/10}$

$u(R) = 0.36$

$n_{eff} = 70$
magnetic fields several coils were developed and depending upon the severity of the influence, five type of tests have been finalized and recommended to CBIP. These have been included in CBIP-88 report as amendment from 5.6.2.1 to 5.6.2.5. During all the five tests no abnormality like movement of digits (for Electrochemical registers), flickering/ switching On-Off of display (for digital display), abnormal heating should occur and the % error should not change beyond the allowed limits.

Test of accuracy of the static energy meter in the presence of only two wires, either neutral and one phase or any two phases without neutral has been included.

**AC High Voltage and Current Standards**

The facility for the calibration of AC Current Ratio for currents up to 5000A at 50 Hz has been upgraded (as shown at Fig. 2.6) from ± 0.005% accuracy to ± 0.001% accuracy. Also the traceability for CT calibrations has been established with PTB, Germany.

This section is also providing calibration facilities by maintaining the National Standards of AC High Current Ratios at power frequencies. Calibration services were provided for Current Transformers, CTTS, Clamp meters, AC Current Shunts, Weld Testers, CTTS Jigs, CT Burdens and for Potential Transformers, PTTS, HV Probe, Electro Static Volt Meters (ESVM), HV Break Down Test Sets and PT Burdens etc. As many as 27 calibration certificates were issued to the electrical manufacturers and utilities.

Work has been planned for extending the range of AC High Voltage Ratio Calibration up to 100 kV at 50 Hz.

**LF & HF Impedance Standards**

This activity is working to establish, maintain and update primary and transfer standards of capacitance, inductance, ac resistance and ac voltage ratio at low and high frequencies. As such this activity provides apex level calibration facilities for the above parameters to various user

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*Fig. 2.6 : Experimental set-up for calibration of AC High Current Ratio (5A-5000A/ 1A,5A) at 50 Hz.*
organizations all over India.

The design and development of Direct Reading Resistance Bridge based on inductive voltage dividers has been completed. The evaluation of this bridge indicates that it can measure 1 k Ohm resistance with a measurement uncertainty of 5 ppm at 1 kHz. This bridge can be used for high precision ac resistance measurements at different frequencies up to 10 kHz. In addition to this it can also be used for primary work related to international inter-comparison of capacitance, to measure the temperatures of capacitance standards in terms of resistance.

Inter-laboratory proficiency testing programmes with NPL as the pilot laboratory have been conducted in the field of capacitance and ac resistance measurements; among the NABL accredited calibration laboratories in India. This programme was coordinated by NPL and funded by NABL, New Delhi.

We participated in the International inter-comparison of AC voltage Ratio under CCEM-K7 key comparison programme. In this inter-comparison 14 laboratories like NIST (USA), PTB (Germany), NPL (UK) – Pilot laboratory, NML (Australia) etc. have participated. The transfer standard IVD (Inductive Voltage Divider) sent by the pilot laboratory were measured for ratios from 0.1 to 1 in steps of 0.1 and from 1/11 to 10/11 in steps of 1/11; at 1 kHz, 10 V and at 50 Hz, 3 V, with an uncertainty of $5 \times 10^{-9}$ and $5 \times 10^{-8}$ respectively.

**LF & HF Voltage, Current & HF and Microwave Power Standards**

Two international comparison have been carried out in low frequency voltage under Asia Pacific Metrology Programme. The details are as follows:

APMP International Comparison of AC-DC Transfer Standards at the lowest attainable level of uncertainty. The comparison is a part of Global Mutual Recognition Arrangement (MRA) process. The comparison has been carried out at a nominal voltage 3 volt in the frequency range 1 kHz to 1 MHz. There are 13 participating countries including Australia, India, Germany, Japan and Korea in the comparison. The relative ac/dc transfer error of the travelling standard with our standard is very low at all frequencies. The coordinating laboratory in this comparison is NML, CSIRO, Australia.

APMP International Comparison of high voltage AC-DC Transfer has been carried out at nominal voltages of 500 and 1000 volts in the frequency range 1 kHz to 100 kHz. The travelling standard has been provided by ITRI, Taiwan. Besides Taiwan, India and Australia there are 8 more participating countries. The relative ac/dc transfer error of the travelling standard with respect to our standard in this comparison also, is very low at all frequencies.

**RF Attenuation and Impedance Standards**

The calibration facilities in attenuation and impedance parameters established in the frequency range 30 MHz to 20 GHz in 50 ohm coaxial system and 3.95 to 26.5 GHz in waveguide system (G-band, Xn-band, X-band, Ku-band and K-band) are being used for the calibration of transfer standards of attenuation and impedance of various user organizations e.g. AMSE Palam, ERTLs, BEL, ISRO, Naval Dockyard etc. To extend the existing calibration facilities up to 40 GHz frequency range, a synthesized signal generator from 10 MHz to 40 GHz frequency range has been procured and Ka-band (26.5 – 40 GHz) waveguide components e.g. slotted line, multi-stub tuners and match terminations have been designed and developed. The experimental setup for the measurement of impedance at Ka-band microwave frequencies is shown in Fig. 2.7.

**Magnetic Standards**

*Setting up Facilities for the Calibration of Search Coils*

Facilities have been established for the calibration of search coils against standard search coils of known
turn-area traceable to PTB, Germany using DC solenoid. The standard search coils with known turn-area available with us are:

$$N.A \text{ (Turn-Area)} = 549.52 \pm 0.50 \text{ cm}^2$$
$$N.A \text{ (Turn-Area)} = 59.34 \pm 0.20 \text{ cm}^2$$

Fig. 2.8 shows the photograph of the standard search coils. Direct comparison technique has been used for the measurement of Turn-area of the search coils. Magnetic flux generated by the standard DC solenoid is measured by the standard search coil as well as by the search coil under calibration and the turn-area of the unknown search coil is determined. The uncertainty in the measurement is ± 1%

**Biomedical Measurements and Standards**

Basic investigations in biological tissues and other materials for ultrasonic and electrical properties have been carried out to enable develop ‘safety standards’ for avoiding side effects on the surrounding tissues. Hard tissues like human teeth and tumours, in particular, have been characterised in detail. A new programme on the ‘development and establishment of standards and calibration facilities for electro-medical equipment’, has been formulated, for better health care in the country. It has been investigated first time that the efficiency of the stone disintegration in lithotripters is enhanced by external acoustic stimulation, wherein the...
Characterization of Biological Tissues

Malignant bone with osteosarcoma

Ultrasonic parameters of bone tumour, osteosarcoma, have been determined, in vitro. Average propagation velocity and attenuation are found to be 1640.44 m/s and 2032 dB/m. The causes of low velocity and high attenuation are the porosity and complex nature of the samples used. Standardizing the data assists in the development of a direct technique for the diagnosis and differentiation of tumours.

Safety Standards

Dosimetry and safety limits

As the ultrasound dosage level is required to be controlled within limits for a particular duration for a particular treatment, to establish the safety limits for ultrasound usage on the biological tissues, it became important to utilize the basic characteristics. Therefore, ultrasonic properties of both soft and hard tissues have been studied and correlated with the anatomy and chemical constituents of the organs or tissues. The effect of ultrasound intensity on the tissue structure, particularly thermal behaviour, has been studied in detail. The safety limitations of ultrasound dosage are established on the basis of these basic findings. The study would help the clinicians to use ultrasound machines with proper dosage level and for proper duration for a particular human body or tissue to be treated.

Safety Standards for Lithotripters

High power acoustic lithotripters are in extensive use, these days, to disintegrate renal calculi, non-destructively. It is investigated first time that acoustic stimulation assists in the enhancement of stone disintegration in lithotripters, used for the removal of kidney stones, without surgery. Safety limits of lithotripter intensity on the human tissues have been studied and discussed, by giving comparative data on the laboratory samples of renal calculi, in vitro.