TIME AND FREQUENCY

During 1995-96, considerable breakthrough was made in STFS, both in terms of improving the time transfer accuracy and in drastically reducing the cost of the receiving set-up. Using compensation technique, the time transfer accuracy was reduced from ± 10 µs to ± 1µs. The receiving set-up was redesigned in collaboration with ER & DC, Trivandrum to bring down its cost from a prohibiting Rs. 2.5 lacs to mere Rs. 50,000. One such model has been sold to M/s. Secure Meters, Udaipur and is performing satisfactorily. STFS decoder with tailor made specifications has also been installed at SLDC, Kalwa.

A study of the reliability and availability of GPS signals over India has been successfully concluded. The effect of degradation of time transfer through GPS satellites has been reduced using an algorithm developed for the purpose.

The calibration of frequency standards has been automated in respect of data taking as well as for the computation of the results.

JOSEPHSON VOLTAGE STANDARD

(i) Calibration of zener diode standard against Josephson Voltage at 1 volt level.

Reassignment of value of secondary standard of DC volt. (Uncertainty = 2 PPM)

(ii) Investigations have been carried on short and long term stability of zener diode standard (in collaboration with DC standard group). Variation in value of standard was observed over a period of 60 days and relative humidity varying from 55% to 90%)

\[ Z_1 \Delta V = -0.41 \text{ ppm for 10\% increase in RH} \]

\[ Z_2 \Delta V = +0.73 \text{ ppm for 10\% increase in RH} \]

Value of zener standards substantially changes with humidity. It is advisable to maintain them in humidity controlled rooms or they should be re-calibrated against Josephson Standard more often (One in a month)

(iii) Work has been initiated on fabrication and characterisation of high precision hall sensors of various materials.

I. High-Tc Thin Films

Indo-French project was completed successfully. Developed high quality YBCO thin films with Tc ~ 89-91K and Jc = 2x10^6 A/cm² at 77K (DC magnetron sputtering technique). Observed spiral growth structures in these films with STM (CEERI, Pilani).

II. High-Tc RF-Squids

Fabricated several BSCCO RF-Squids. Developed suitable encapsulation technique to stop degradation in characteristics of squids with time and thermal cycles/moisture. Collaborated with CEERI, Pilani on development of RF-squid electronics.

Supplied one BSCCO RF-Squid probe to CEERI, Pilani for day to day testing of the electronics being developed there. Designed and fabricated cryostat & shielding arrangement for the RF-Squid. Testing and evaluation in progress.

Experimentally confirmed for the first time that natural grain boundaries behave as Josephson weaklings in electron-doped NdCeCuO superconductor. First observation
of RF-squid effect due to natural grain boundary weaklinks in YNi$_2$B$_2$C superconductors. A sensitive magnetic field sensor based on harmonic generation effects in high-Tc superconductors has been developed. Observation of Squid behaviour in Hg (Tl) Ba-Ca-O thin film upto 117.5K, the highest temperature at which squid has ever been operated. Earlier, in 1994 IBM group reported DC-squid characteristic upto 111.8K in Hg-1223 film. Development has been done of a novel non-contact technique for measurement of Tc of superconducting samples of irregular shape and very small size.

**MICROWAVE SUPERCONDUCTIVITY**

Microwave surface resistance measurements have been carried out YBCO thin films using parallel plate dielectric resonator designed and fabricated at NPL. The variation of surface resistance with temperature, microwave frequency, dc and rf magnetic fields have been measured.

A modified and plate replacement technique has been developed for measurement of microwave surface resistance of HTS samples of small dimensions.

A systematic study of magnetic penetration depth $\lambda$(O) for bulk and thin film samples of YBCO has been carried out as a function of density and frequency. $\lambda$(O) decreases with increase in density and is minimum for c-axis oriented thin films. $\lambda$(O) is independent of frequency in the range 10-26.4 GHz.

YBCO thin film microstrip resonator has been designed & fabricated. Various characteristics of the resonator, such as quality factor, insertion loss and frequency shift as a function of temperature and input incident power have been measured.

**AUGER STUDIES**

Electron spectral studies have been carried out on YBCO thin films. The strength of electron correlation and changes in Cu valence for in plane carriers has been found crucial to sustain superconductivity. Doping of Pr ions changes the copper valency which causes suppression of superconductivity.

**LF & HF IMPEDANCE STANDARDS**

(i) The work on fabrication of 1000 MHz high precision admittance bridge in collaboration with Slovak Institute of Metrology has started. One of the four arms of the bridge has been constructed at NPL workshop. The rest of the bridge will be constructed after electrical evaluation of this arm has been completed.

(ii) The design and development of a set of high frequency inductance standards has been completed. This set consists of three inductors having nominal values of 1, 10 and 100 $\mu$H. This set will be used for calibration and performance evaluation of 4-TP LCR meters etc.

(iii) A 10 pF reference standard capacitor of parallel plate configuration has been designed, fabricated and assembled. Its stability has been studied for a period of more than one year and as such it is found to be stable within 20 ppm per year. It is now ready for hermetically sealing.

(iv) A new facility has been set up for measurement of tan $\delta$ of capacitors upto 100 V at 1 kHz.

(v) A new facility for absolute calibration of Transformer Ratio Standards has been set up. This set up can measure transformer ratio with an uncertainty of $\pm$ 0.03 ppm.

(vi) The automated IVD (Inductive Voltage Divider) calibration set up has been modified to improve the measurement accuracy from 0.1 ppm to 0.05 ppm.

**AC & LF STANDARDS**

1. *Power & Energy Measurements*

   1. Facility for phase current measurement


under 17.5% of 3RD harmonics distortion in current paths.

2. **Improvement of Measurement Uncertainty for**
   - 3φ system: from + 0.05% to 0.03%
   - 1φ system: from + 0.03% to 0.02%

3. **Bilateral comparison of watt Converter**
   - (+ 0.02%) PTB Germany/NPL India. Tally of results: within 80 ppm

(II) **AC High Current & High Voltage Standards**

1. **Facility for the calibration of PTTS JIG**
   - **Accuracy**: ± 0.1%

2. **Extension of the range for calibration of**
   - **Weld Testers/Scopes from 10 kA to 15 kA at 50 Hz**
   - **Accuracy**: ± 1%

3. **Bilateral comparison of reference standard current transformer with PTB Germany.**
   - **Tally of Results**: Within ± 0.03%

4. **Facility established for the calibration of CT burdens at 50 Hz**
   - **Accuracy**: ± 1%

**HF & MW Voltage, Current, Power, Frequency and Noise**

This group is working for the establishment, maintenance and updating of primary and transfer standards of AC and LF voltage and current. HF and MW power and noise in the frequency range of 10 Hz to 26 GHz. This activity provides apex level calibration facilities for the above parameters to user organisations all over India.

(i) **International intercomparison of multi junction thermal converters (primary std. of LF voltage) has been carried out under BIPM umbrella with 11 laboratories under euromet loop and 11 laboratories in world wide loop. 3 volt MJTC was intercompared at 1 kHz, 20 kHz, 100 kHz and 1 MHz. The intercomparison was carried out on a fully automated setup which was designed at NPL. The relative AC_DC transfer error of NPL MJTC with respect to PTB MJTC is within ± 5 PPM upto 100 kHz and ± 20 PPM at 1 MHz which indicates an excellent agreement in NPL and PTB LF voltage standards.**

(ii) **Automation introduced in the calibra**

(iii) **One voltage calibration tee has been fabricated based on PTB design for voltage calibration work in the 10 MHz to 1000 MHz frequency range.**

(iv) **Evaluation of coaxial microcalorimeter further continued and results are being summarized.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Accuracy of Standard</th>
<th>Measurement Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF Voltage (10 Hz-100 KHz)</td>
<td>2X E-06 to 1.5X E-05</td>
<td>±0.005% - ± 0.01%</td>
</tr>
<tr>
<td>LF Current (10 Hz-100 kHz)</td>
<td>do</td>
<td>± 0.01% - ± 0.05%</td>
</tr>
<tr>
<td>HF Voltage (1MHz - 1GHz)</td>
<td>1X E-04 to 5XE-03</td>
<td>± 0.05% - ± 5%</td>
</tr>
<tr>
<td>HF &amp; MW Power (1 MHz - 18 GHz)</td>
<td>2 X 1E - 03</td>
<td>± 0.5% - ± 1.5%</td>
</tr>
<tr>
<td>HF &amp; MW Noise (1 K (ENT)) (ENR)</td>
<td>1 K</td>
<td>± 0.32 dB</td>
</tr>
</tbody>
</table>

**HF & Microwave Attenuation and Impedance Standards**

Calibration facilities were upgraded for coaxial fixed & variable attenuators in the frequency range 1-18 GHz in coaxial & waveguide systems using AF Substitution Technique & IF Substitution Technique.

For coaxial & waveguide standard mismatches coupled sliding load technique tuned reflectometer technique (Xn-, X & Ku-
band microwave frequencies) using indigenously designed & developed impedance standards e.g., Quarter wave short circuits, Precision waveguides, match terminations etc.

**MAGNETIC STANDARDS**

Facilities have been established for the calibration of fluxmeters using volt-second generator with an over all uncertainty better than ± 0.5%.

Search coils of different turn-areas used for the measurement of flux have been designed and fabricated. Results have shown good agreement between calculated and experimental values of turn-areas.

A multilayered one meter long standard solenoid has been designed and fabricated in NPL workshop. Preliminary measurements are in progress.

Measurements conducted for studying variations in geomagnetism during solar eclipse (24th Oct., 1995) at NPL, New Delhi. Pronounced effect on the variation of vertical component of magnetic field observed. Both the vertical component and the total magnetic field intensity remained depressed by about 250 nT.

Extension of flux density measurement range from 10000 gauss to 15000 gauss. Work has been initiated for the fabrication of Hall probes of different materials in collaboration with JVS & squid group.

Helped the following groups of NPL in conducting magnetic measurements

i) JVS & Squid Group

ii) Thin Film Group

iii) Cryogenics Division

AC measurement setup for soft magnetic materials is ready for testing and calibration. NMR measuring set-up ready for evaluation. Electromagnets and power supply to be tested at Bruker co., Germany before being sent to NPL, India.