

9<sup>th</sup> International Conference  
*on*  
"Advances in Metrology"

**AdMet–2016**

(February 24-26, 2016)

and

**Pre–AdMet Workshops**

(February 22-23, 2016)



*Jointly Organized by*

**CSIR–National Physical Laboratory**

([www.nplindia.org](http://www.nplindia.org))

Dr. K.S. Krishnan Road, New Delhi-110012, India

and

**Metrology Society of India (MSI)**

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## Pre-AdMet Workshop on "Metrology in Chemistry: Ambient Air Quality Measurements"

Date: 23<sup>rd</sup> February, 2016 • **Venue** : CSIR-National Physical Laboratory, New Delhi-110012, INDIA  
Jointly organized by CSIR-NPLI, MSI and WMO/GAW

### Technical Program

9:00-9:30 h	Registration
9:30-9:40 h	Welcome by Director, NPLI
9:40-9:50 h	About workshop by Prabhat K. Gupta
9:50-10:30 h	Paolo Laj, Executive Editor - AMT Chair of Scientific Advisory Group on Aerosol GAW/WMO, France "Concepts for a sustainable international aerosol network"
10:30-10:50 h	<b>Tea</b>
10:50-11:30 h	Alfred Wiedensohler, Editors-in-Chief - AE World Calibration Center for Aerosol Physics, Germany "The world calibration center for aerosol physics - duties and measures for quality assurance"
11:30-12:10 h	S.D. Attri, Dy Director General, IMD, India "QA/QC challenges in environmental monitoring"
12:10-12:50 h	C.J. Tsai, Editors-in-Chief - AAQR, NCTU, Taiwan "PM <sub>2.5</sub> sampling and artifacts"
12:50-13:50 h	<b>Lunch</b>
13:50-14:30 h	S.K. Tyagi, CPCB, India "Air quality monitoring in India: Issues and challenges"
14:30-15:10 h	C. Sharma, NPLI "Ambient air quality monitoring at Himalaya region"
15:10-15:30 h	<b>Tea</b>
15:30-16:10 h	S. G. Aggarwal, NPLI "Air quality metrology"
16:10-16:50 h	Markus Fiebig, World Data Center on Aerosol, Norway "Management of aerosol data in GAW: making data count for global applications"
16:50-17:30 h	Presentation from industries and panel discussions chaired by Prabhat K. Gupta
17:30 h	Closing of the workshop

## Two days Pre-AdMet Workshop on Best Practices in Measurement and Evaluation of Uncertainty

CSIR-National Physical Laboratory, New Delhi

**Venue :** TEC Conference Room

### Programme Schedule

<b>February 22, 2016</b>		
09:30 - 09:45	Registration	
09:45 - 10:00	Welcome of the Participants and about the Workshop by Dr. V. N. Ojha, HOD, ALSIM	
<b>Time</b>	<b>Speaker</b>	<b>Title of the talk</b>
10:00 - 10:30	Mr. Anil Relia, Director, NABL	Accreditation process
<b>Tea (10:30 - 11:00)</b>		
11:00 - 11:30	Mr. B. Dixit, Director, Legal Metrology	Legal Metrology
11:30 - 12:30	Mr. S. K. Kimothi, Ex-Director, ERTL(N)	Best Practices in Measurements
12:30 - 13:30	Dr. K. P. Chaudhary, Ex-Chief Scientist, CSIR-NPL	Excellence in measurements
<b>Lunch (13:30 - 14:30)</b>		
14:30 - 15:30	Hands-on training	
<b>Tea (15:30 - 15:45)</b>		
15:45 - 17:00	Hands-on training	
<b>February 23, 2016</b>		
<b>Time</b>	<b>Speaker</b>	<b>Title of the talk</b>
9:30 - 10:30	Dr. V. N. Ojha, Chief Scientist, CSIR-NPL	Basics in Metrology and Evaluation of Uncertainty
10:30 - 11:30	Mr. Anil Kumar, Chief Scientist, CSIR-NPL	Requirements of ISO/IEC 17025
<b>Tea (11:30 - 11:45)</b>		
11:45 - 12:30	Mr. D. K. Nayyar, Scientist G & Dy. DG (Standardization), BIS	Standards and Standardization Process
12:30 - 13:15	Mr. A. K. Saxena, Ex-Chief Scientist, CSIR-NPL	Quality system and CMC approval
<b>Lunch (13:15 - 14:15)</b>		
14:15 - 16:15	Hands-on training	
<b>Tea (16:15 - 16:30)</b>		
16:30 - 17:00	Valedictory Session and Certificates distribution	

## 9<sup>th</sup> International Conference on Advances in Metrology (AdMet-2016) (February 24-26, 2016)

CSIR-National Physical Laboratory, New Delhi

### Technical Program

<b>Day-1</b>		<i>Date : 24/02/2016</i>
08:30 to 09:15 h	Registration	
09:15 to 09:35 h	Inauguration	
09:35 to 10:25 h	<ul style="list-style-type: none"> <li>• Lamp lighting</li> <li>• Welcome by Dr. D.K. Aswal, Director, CSIR-NPL</li> <li>• About the conference by Dr. A. Sen Gupta, President MSI &amp; Conference Chair, AdMet-2016</li> </ul>	
10:25 to 10:30 h	<ul style="list-style-type: none"> <li>• Keynote address by Dr. M. Milton, Director, BIPM (Chief Guest)</li> <li>• Vote of thanks by Dr. Y.P. Singh, Convener, AdMet-2016</li> </ul>	
10:30 to 11:00 h	<b>Tea / Coffee</b>	
11:00 to 11:40 h	Plenary Talk1 : Dr. Kamal Hossain (NPL, UK), Material Metrology Metrology for Grand Societal Challenges	
	Technical Session 1 : Quantum Metrology	
11:45 to 12:10	Invited Talk1 : Dr. Michael Podesta (NPL, UK) Beyond the International Temperature Scale of 1990	
12:10 to 12:35	IT2 : Dr. Yi Hua Tang (NIST, USA) Voltage Metrology, Watt Balance and the SI Redefinition	
12:35 to 13:00	IT3 : Prof. R.C. Budhani (Ex-Director, CSIR-NPL; IIT, Kanpur) The Pivotal Role of Superconductivity in the Development of Quantum Metrology	
13:00 to 14:00	<b>Lunch and Poster</b>	
	TS2 : Temperature and Optical Metrology	
14:00 to 14:25 h	IT4 : Dr. Stefan Kueck (PTB, Germany) Recent Advances in The Detection Efficiency Calibration of Silicon Single-Photon Avalanche Diodes using Double Attenuator Technique	
14:25 to 14:50 h	IT5 : Dr. Y.P. Singh (CSIR-NPL) Advances and Challenges in Temperature Metrology	
14:50 to 15:15 h	IT6 : Dr. Armin Sperling (PTB, Germany) Calibration and Testing of Light Sources Based on LEDs and OLEDs	
15:15 to 15:40 h	IT7 : Mr. Richard Timmons (Guildline Instruments, Canada) New DC Temperature Bridge Technology - Design and Performance	
15:40 to 16:05 h	IT8 : Dr. Ranjana Mahotra (CSIR-NPL) Surface Enhanced Raman Spectroscopy in Molecular Detection, Diagnosis and Therapy	
16:05 to 16:30 h	<b>Tea and Poster</b>	
	TS3: Pressure, Vacuum and Fluid Flow Metrology	
16:30 to 16:55 h	IT9 : Dr. Tokihiko Kobata (NMIJ, Japan) Effective Utilization of Industrial Digital Pressure Gauges in International Comparisons	

16:55 to 17:20 h	IT10 : Dr. A.K. Bandyopadhyay (Rtd. Chief Sci. CSIR-NPL) A Novel Approach Towards The Determination of E-Mass by Differential Pressure Measurement
17:20 to 17:50 h	IT11 : Dr. Sanjay Yadav (CSIR-NPL) Metrological Equivalence, Traceability and Dissemination of National Pressure Standards and Some New Developments
17:50 to 18:25 h	IT12 : Mr. S.K. Jaiswal (CSIR-NPL) An Overview of Fluid Flow Testing and Calibration Facilities at CSIR-National Physical Laboratory (NPLI)
	<b>Evening Lecture</b>
18:30 to 19:20 h	Dr. A. Sen Gupta (President MSI)
20:00 to 21:30 h	<b>Dinner</b>
<b>Day-2</b>	<b>Date : 25/02/2016</b>
08:30 to 09:00 h	Registration
09:00 to 09:40 h	PT2 : Dr. Joachim Ullrich (President PTB, Germany), SI Units The Silicon Route Towards the New SI
09:40 to 10:20 h	PT3 : Prof. C. J. Tsai (NCTU, Taiwan), Particulate Metrology Particulate Metrology: Toward Accurate Ambient PM2.5 Ambient Sampling and Monitoring
10:20 to 10:40 h	<b>Tea/Coffee and Poster</b>
10:40 to 11:15	PT4 : Dr. D.K. Aswal (Director, CSIR-NPL) TS4 : General Metrology
11:20 to 11:45 h	IT13 : Prof. E.S.R. Gopal (Ex-Director, CSIR-NPL) Leap Years, Leap Centuries and Leap Seconds: Less Known Interesting Facts
11:45 to 12:10 h	IT14 : Dr. Wu Fangdi (Dy Director, NMI, China) NIM, Today and in Future
12:10 to 12:35 h	IT15 : Prof. Krishan Lal (Ex-Director, CSIR-NPL) Increasing Sensitivity of Experimental Techniques Leads to New Insights: High Resolution X-ray Diffraction Experiments
12:35 to 13:00	IT16 : Prof. K.S. Nagla (NIT, Jalandhar) Multi Sensor Data Fusion in Mobile Robots
13:00 to 13:50 h	<b>Lunch and Poster</b> TS5 : Accreditation, Legal Metrology
13:50 to 14:15 h	IT17 : Dr. Anil Relia (Director, NABL)
14:15 to 14:40 h	IT18 : Dr. B.N. Dixit (Director, W&M, Legal Metrology) TS6 : Length, Dimension and Nano Metrology
14:40 to 15:05 h	IT19 : Dr. V.N. Ojha (CSIR-NPL) Needs and Challenges in Nanometrology: Role of National Measurement Institute
15:05 to 15:30 h	IT20 : Dr. K.P. Chaudhary (CSIR-NPL)
15:30 to 15:55 h	IT21 : Prof. S.H. Pawar (VC, D. Y. Patil Univ., Kolhapur) Critical Role of Nanometrology in Biological and Medical Sciences
15:55 to 16:20 h	IT22 : Dr. Rina Sharma (CSIR-NPL) Dimensional Nanometrology: Needs, Challenges and Status at NPL India

16:20 to 16:50 h	<b>Tea/Coffee and poster</b> TS7 : Metrology in Chemistry, Environment and Health
16:50 to 17:15 h	IT23 : Dr. Prabhat K. Gupta (CSIR-NPL) Realization of Mole under Metrology in Chemistry Activity: Current Status and Future Plan
17:15 to 17:40 h	IT24 : Prof. Ravinder Agarwal (Thapur University) Agriculture Crop Residue Burning in Indo Gangatic Plains: A Global Threat
17:40 to 18:30 h	Presentations from sponsoring companies (10 min each) Mitutoyo South Asia Pvt. Ltd., New Delhi Fluke Technologies Pvt. Ltd., New Delhi Advance Technical Systems Pvt. Ltd., New Delhi WIKA Instruments India Pvt. Ltd., Delhi Octagon Precision India Pvt Ltd., Pune
18:30 to 19:00 h	Poster Session
19:00 to 20:00 h	Cultural Event
20:00 to 21:30 h	<b>Dinner</b>
<b>Day-3</b> <span style="float: right;"><i>Date : 26/02/2016</i></span>	
09:00 to 09:40 h	PT5 : Dr. James K. Olthoff (NIST, USA), Physical Metrology Embedded Measurements- The Future of Metrology
09:40 to 10:20 h	PT6 : Dr. Jorge C. Torres Guzman (CENAM, Mexico), Mechanical Metrology
10:20 to 10:40 h	<b>Tea/Coffee and Poster</b> TS8 : Electrical and Magnetic Metrology, Time and Frequency
10:40 to 11:05 h	IT25 : Dr. R.K. Kotnala (CSIR-NPL) International Magnetic Standards on Electrical Steel to Hydroelectric Cell as Green Energy Solution
11:05 to 11:30 h	IT26 : Mr. Thomas John (CSIR-NPL) LF, HF Impedance & DC Standards at CSIR-NPL: Present Status
11:30 to 11:55 h	IT27 : Mr. P.S. Negi (CSIR-NPL) Importance of NMIs Participation in BIPM Key/ Supplementary Inter-comparisons
11:55 to 12:20 h	IT28 : Mr. M.A. Ansari (CSIR-NPL) Present Status and Future Plan of AC High Voltage and High Current Standards at CSIR-NPL
12:20 to 12:45 h	IT29 : Dr. H. K. Singh (CSIR-NPL) Recent progress in quantum Hall effect resistance metrology
12:45 to 13:10 h	IT30 : Dr. Ashish Agarwal (CSIR-NPL) Time and Frequency Metrology at NPL India
13:10 to 13:50 h	<b>Lunch and Poster</b> TS9 : Mass, Force Metrology
13:50 to 14:15 h	IT31 : Dr. Jin-Wan Chung (KRISS, Korea)
14:15 to 14:40 h	IT32 : Mr. Anil Kumar (CSIR-NPL) Mass Realization in Legal Metrology Way
15:05 to 15:30 h	IT33 : Dr. S.S.K. Titus (CSIR-NPL) Facilities Established at CSIR-NPL for the Realization and Dissemination of Force, Torque and Hardness Measurements



15:30 to 16:00 h	Presentaions by exhibition stall holders (5 min each)
16:00 to 16: 30 h	Closing
16:30 to 18:00	<b>Tea and AGM of MSI</b>

**Venue :** Registration desk will be situated at Dr. A. R. Verma lawn (in front of auditorium NPL).  
All talks and functions will be held at auditorium NPL



# PLENARY TALKS



## **Metrology for Grand Societal Challenges**

**Kamal Hossain**

*National Physical Laboratory, Teddington, UK*

### **Abstract**

Metrology has a vital underpinning role in global trade, industrial productivity and competitiveness. It also serves as an essential tool for scientific research and development and innovation. Fundamental work on metrology carried out mostly by National Metrology Institutes (NMI) is concerned with the development, maintenance and dissemination of the international system of units (SI) and Measurement Standards. These standards enable traceable measurements to be made for all sectors and across the globe.

Increasingly, as our modern society faces grand challenges such as the provision of advanced, safe and cost-effective healthcare to citizens, secure supply of clean and affordable energy, and the sustainability of our environment we live in, there is recognition and awareness that new and reliable measurement technologies with traceability are needed urgently. Successful development of the necessary measurement capability will be crucial for meeting these societal challenges.

Development of such measurement techniques often requires tools and techniques involving multidisciplinary metrology, and the engagement of end users and stakeholders is critical. Furthermore, the resources required to develop metrology to meet grand challenges places heavy demand on individual countries and Governments. For cost effective and timely development, many countries in Europe have joined forces and initiated major metrology research programmes with shared funding from the European Commission to deal with metrology for grand challenges.

This talk will cover the key measurement challenges in Europe in healthcare, energy, and environmental sustainability and how NMIs are working together to address these challenges. Results from some key projects and their impacts will be discussed.

## The Silicon Route towards the New SI

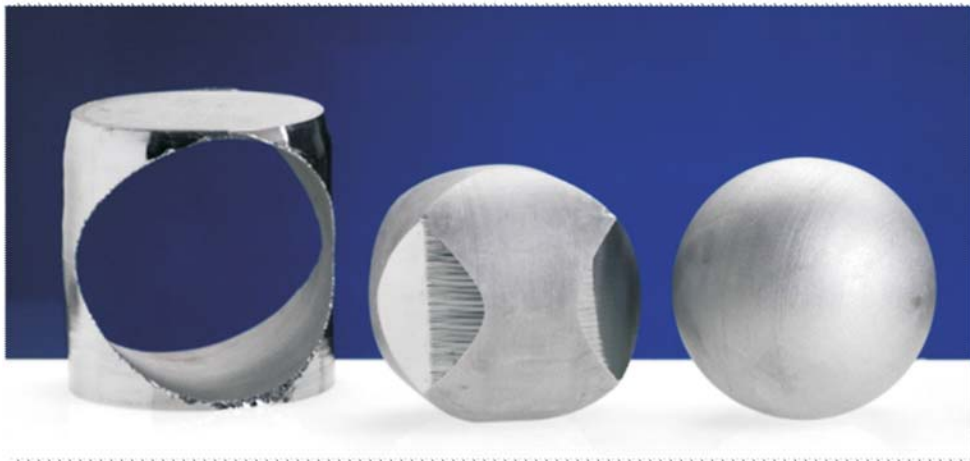
Joachim Ullrich

*Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany*

### Abstract

In 2018, on the occasion of the 25<sup>th</sup> meeting of the General Conference on Weights and Measures, CGPM, it is envisaged to redefine the International System of Units (SI). In the future, it shall be based on fixing the numerical values of fundamental constants of nature, the "defining constants": the velocity of light, the charge of the electron, the Boltzmann, Avogadro and the Planck constants, the Cs hyperfine clock transition and the luminous efficacy.

In the talk an overview will be provided on the challenges, progress and present status of the International Avogadro Collaboration project (IAC) to measure the Planck (Avogadro) constant by counting the number of atoms in a crystal sphere of enriched silicon. The future perspectives as to the realisation after redefinition will be envisioned.



Towards the silicon crystal sphere

**Keywords:** Boltzman, Avogadro and Plank consultant

## Particulate Metrology: Toward Accurate Ambient PM<sub>2.5</sub> Ambient sampling and monitoring

Chuen-Jinn Tsai

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(\*E-mail: cjtsai@mail.nctu.edu.tw)

### Abstract

Currently, manual US EPA FRM (Federal Reference Method) PM<sub>2.5</sub> samplers and real-time FEM (Federal Equivalent Method) monitors are used for measuring ambient PM<sub>2.5</sub> concentrations to determine the compliance with PM<sub>2.5</sub> air quality standards. However, the difference in PM<sub>2.5</sub> between these measurements and actual ambient level often exists due to the existence of sampling artifacts. Field results showed that due to evaporation loss, PM<sub>2.5</sub> concentrations measured by the FRM WINS PM<sub>2.5</sub> sampler (WINS), Dichotomous sampler (Dichot) were lower than those by the TEOM-FDMS (tapered element oscillating microbalance-filter dynamic measurement) PM<sub>2.5</sub> FEM by  $16.6 \pm 9.0$  and  $15.2 \pm 10.6$ . However, when PM<sub>2.5</sub> concentrations were corrected for the evaporation loss determined by using a porous-metal denuder sampler (PDS), good agreement with those by the TEOM-FDMS was achieved. Results showed that the evaporation loss of PM<sub>2.5</sub> was severe during sampling, accounting for 5.8 to 36.0 % of the PM<sub>2.5</sub> concentration and the deviation increased with decreasing loaded particle mass and increasing filtration velocity. Lowering the incoming aerosol temperature and humidity was shown to reduce the evaporation loss considerably leading to much more accurate PM<sub>2.5</sub> sampling. Field experimental results will be reported in this talk.

Semi-continuous chemical composition measurement for PM<sub>2.5</sub> is as important as that for mass concentration as sources and meteorological condition are ever-changing. The accuracy of an Aerosol Chemical Speciation Monitor (ACSM) for monitoring the inorganic soluble ions was evaluated using a PPWD-PILS (Parrel-Plate-Wet-Denuder Particle-into-Liquid Sampler) monitor. The latter was first validated using the manual PDS. It was found that the agreement was poor when the PM<sub>1</sub> aerodynamic lens was used. For comparison when a new PM<sub>2.5</sub> lens was used, the agreement was much better improved for NH<sub>4</sub><sup>+</sup> and SO<sub>4</sub><sup>2-</sup> with  $R^2 > 0.78$ . The CMB results showed that SOA was the main component of organic aerosols in Judong and NCTU campus, which are sub-urban sites, due to photochemical reaction, representing  $62.2 \pm 16.3$  and  $65 \pm 19.3\%$  of organic aerosols, respectively. In contrast, POA was the main component of organic aerosols in Sinjhung, which is the urban site, due to traffic emission, representing  $61 \pm 2.54\%$  of the total organic aerosols. The conversion factors of OC measured by the Sunset OC/EC field analyzer to OM measured by the ACSM in Judong, Sinjhung and NCTU campus were  $1.63 \pm 0.76$ ,  $1.93 \pm 1.84$  and  $1.61 \pm 0.79$ , respectively.

**Keywords:** PM<sub>2.5</sub>, Particulate metrology, Aerosol measurement, Secondary aerosols.

## **Embedded Measurements – The Future of Metrology**

**James K. Olthoff**

*National Institute of Standards and Technical (Physical Measurement  
Laboratory, NIST, Gaithersburg, MD USA)*  
(E-mail : james.olthoff@nist.gov)

### **Abstract**

Improved dissemination of national standards is a primary priority of the Physical Measurement Laboratory (PML) of NIST in order to advance U.S. commerce and spur innovation. To meet industry’s need for every more precise and reliable measurements, NIST has embarked upon a program to develop embedded standards that will provide quantum-based measurements wherever industry needs them. This program is intended to revolutionize measurement services and measurement science through development and dissemination of “NIST-on-a-Chip” technologies. In general, these would consist of ultra-miniature measurement tools based on quantum sensors and photonic circuits, and traceable to NIST standards and the SI that are designed and produced to meet the performance and cost needs of specific applications. Current devices invented and/or developed within PML include: chip-scale atomic clocks, magnetometers and related devices; microscale laser frequency combs to flexibly link input/output with quantum measurements; quantum-based electrical measurements; photonic and mechanical precision thermometry; micro-force measurement techniques; quantum pressure measurement systems; microfluidic-based measurements of chemical and physical properties; micro-opto-mechanical systems combining broad ranges of measurement capabilities; and unique micro/nanofabrication and characterization capabilities. Eventually it is anticipated that this research will enable the integration of a broad range of precision measurement technologies into single, small-form system that can be utilized for many applications.

This talk will highlight the goals and anticipated impact of this program, the significant progress made so far, and plans for the future. It will also present the impact of the development of these capabilities on the future role of national metrology institutes.

**Keywords:** Embedded standards, Quantum standards, Miniaturization



**INVITED  
TALKS**



## Beyond the International Temperature Scale of 1990

Michael de Podesta<sup>1</sup>, Robin Underwood<sup>1</sup>, Gavin Sutton<sup>1</sup>, Leigh Stanger<sup>1</sup>,  
Richard Rusby<sup>1</sup>, Peter Harris<sup>1</sup>, Paul Morantz<sup>2</sup>, Graham Machin<sup>1</sup>

<sup>1</sup>*National Physical Laboratory (NPL), Teddington, Middlesex, UK*

<sup>2</sup>*School of Applied Sciences, Cranfield University, Cranfield, Bedfordshire MK43 0AL, UK*

### Abstract

The *International Temperature Scale of 1990* (ITS-90) is an approximation to thermodynamic temperature, and provides a practical scale that is the reference method for dissemination of the kelvin. By following the procedures of ITS-90, users worldwide are able to produce approximations, called  $T_{90}$ , to thermodynamic temperature,  $T$ , based on primary thermometry results published prior to 1990. However, advances in primary thermometry since 1990 - most notably developments in acoustic gas thermometry - have revealed differences between  $T_{90}$  and  $T$  which approach 1 part in  $10^4$ .

In this talk I will describe the NPL-Cranfield combined acoustic and microwave resonator and its use as a primary thermometer. After describing its use in our measurement of the Boltzmann constant, I will present our recent estimates of  $T/T_{90}$  in the temperature range from 118 K to 303 K [1], highlighting the procedures that have enabled exceptionally low uncertainty. Significantly, the uncertainty associated with primary thermometry is now lower than that achievable using standard platinum resistance thermometers. I will then discuss the implications of this work for the future of ITS-90, and whether a new temperature scale is required.

[1] Estimates of the difference between thermodynamic temperature and the ITS-90 in the range 118 K to 303 K, R. Underwood, M. de Podesta, G. Sutton, L. Stanger, R. Rusby, P. Harris, P. Morantz, G. Machin. Accepted for publication in *Philosophical Transactions of the Royal Society A*.

### Keywords:

## Voltage Metrology, Watt Balance and the SI Redefinition

Yi-Hua Tang

*NIST, USA*

### Abstract

Planck constant,  $h$  is one of the seven fundamental constants proposed to redefine the SI. It has been measured by the Watt balance experiment since the 1980s. In its early days, the Watt balance experiment played a vital role in determining the Josephson constant  $K_{J-90}$  which was adopted internationally on January 1, 1990. The development of Josephson technologies, especially the implementation of Programmable Josephson Voltage Standard (PJVS) in voltage metrology has greatly improved the uncertainty of voltage measurement in the Watt balance by more than an order of magnitude. The intertwined interaction between voltage measurement technology and the Watt balance plays an important role in the proposed SI redefinition based on a set of fundamental constants. This talk will present a brief history from the original NIST Watt balance in 1980s up to the most recent development of NIST-4 Watt balance and the impact that this experiment has had on the voltage metrology.

### Keywords:

**The Pivotal Role of Superconductivity in the  
development of Quantum Metrology**

**R.C. Budhani**

*Indian Institute of Technology Kanpur, Kanpur 208016, India  
Former Director National Physical Laboratory (2009-2014)*

## Recent Advances in the Detection Efficiency Calibration of Silicon Single-Photon Avalanche Diodes using Double Attenuator Technique

S. Kück<sup>1</sup>, M. López<sup>1</sup>, K. Dhoska<sup>2</sup>, T. Kübarsepp<sup>2,3</sup>, H. Hofer<sup>1</sup> and B. Rodiek<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116, Braunschweig, Germany

<sup>2</sup>Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia

<sup>3</sup>AS Metrosert, Teaduspargi 8, 12618 Tallinn, Estonia

(\*E-mail : stefan.kueck@ptb.de)

### Abstract

In recent years, a calibration technique for the detection efficiency calibration of silicon single-photon avalanche diodes (Si-SPADs) was developed at the Physikalisch-Technische Bundesanstalt (PTB), the German National Metrology Institute [1, 2]. The major uncertainty contributions were the uncertainty of the absolute responsivity measurement of the reference detector and the filter transmission measurement, leading to a standard uncertainty of  $\sim 0.3\%$  [2]. In this paper we report on the recent progress for reducing the measurement uncertainty. One major improvement in the calibration setup, see Figure 1, was achieved by implementing an integrating sphere with Si-diode as standard detector. Thereby, the uncertainty contribution due to the filter transmission measurement is practically negligible, because specular back reflections into the setup are avoided. Furthermore, the setup is less affected by the beam size. The relative standard measurement uncertainty achieved for the Si-SPAD detection efficiency is now as low as  $\sim 0.16\%$ . The complete experimental results involved for achieving this standard uncertainty will be shown at the conference.

Furthermore, the investigation of the detection efficiency homogeneity of Si-SPAD detectors as well as first attempts towards a direct calibration of a Si-SPAD against a Si-standard diode will be presented.

### Acknowledgement

This work was funded by the project "Single-Photon Sources for Quantum Technology" (SIQUTE) of the European Metrology Research Programme (EMRP). The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union.

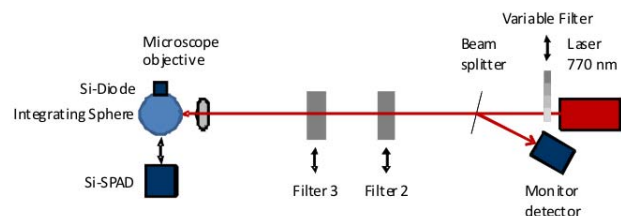


Fig. 1: Scheme of the set-up used for the calibration.

[1] C. J. Chunnillall, I. P. Degiovanni, S. Kück, I. Müller, and A. G. Sinclair, "Metrology of single-photon sources and detectors: a review", *Opt. Eng.*, **53**(8), 081910-1 - 081910-17 (2014).

[2] M. López, H. Hofer, S. Kück, "Detection efficiency calibration of single-photon silicon avalanche photodiodes traceable using double attenuator technique, *Journal of Modern Optics* 62, S21 - S27 (2015), <http://dx.doi.org/10.1080/09500340.2015.1021724>.

**Keywords:** Detection efficiency, Si-SPAD, Calibration, Radiometry

## Advances and Challenges in Temperature Metrology

Y.P. Singh

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(Email: ypsingh@nplindia.org)

### Abstract

Temperature is one of the seven base quantities and its unit, kelvin, K is presently defined, *a fraction 1/273.16 of the thermodynamic temperature of triple point of water (TPW)*, a temperature which is fixed by definition in the International Temperature Scale of 1990 (ITS-90). It is a temperature at which the three phases of pure water i.e. solid, liquid and vapor coexist together as shown in Fig.1. Although the temperature of this fixed point is realized by highest precision thermometer, SPRT to the highest degree of precision in terms of uncertainty (of the order of,  $u \sim 3 \times 10^{-7}$ , CODATA) but its value of realization always has dependency on the properties of water. The temperature scale at present is defined basically by three parameters namely reliable thermal sources (fixed points), defined standard instrument of highest accuracy in the range of best application (SPRT or photoelectric radiation pyrometer) and mathematical equations relating temperature with the indication of the defined instrument. With the advent of high precision requirement of temperature and independency of unit with respect to material property, it has made attraction to define temperature in terms of fundamental constant or quantum definition. Over the years, a lot of work had been going on in the leading laboratories around the world like NIST USA, NPL UK, PTB Germany, NMIJ Japan, KRISS Korea and many more to define the unit of temperature kelvin, in terms of fundamental constant. Boltzmann constant,  $k_B$  is the fundamental constant which always appears as coefficient of thermal energy,  $k_B.T$ . Hence it becomes more reliable to define the unit of temperature in terms of  $k_B$ . There have been several methods of realizing Boltzmann constant but acoustic gas thermometry is the one which has demonstrated the lowest uncertainty of measurement ( $u \sim 1 \times 10^{-6}$ ), that most of the laboratories have determined. The new definition that has been proposed would be as *"the unit of thermodynamic temperature, kelvin, K is the temperature which brings a change in the thermal energy of  $1.38064852 \times 10^{-23}$  Joules*, the apparatus shown in Fig.2. This talk will present some of the new challenges and important issues for redefining the unit in the future temperature scale. NPL, India has started this project of realization of  $k_B$  by using acoustic gas thermometry and it is expected that by 2018 a significant amount of task would be completed when new definition would be officially announced by BIPM, France.

**Keywords:** Triple point of water, Fixed points, Fundamental constant, Acoustic gas thermometry, Thermal energy, SPRT, Photoelectric radiation pyrometer, Uncertainty.

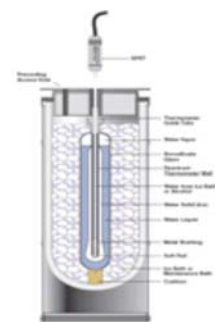


Fig. 1. TPW Cell



Fig.2 Apparatus

## Calibration and Testing of Light Sources based on LEDs and OLEDs

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### Abstract

The worldwide phase-out of incandescent lamps used for general lighting has a big influence not only on the development of possible replacements, but also on the metrology for lighting. On the one hand side, modern light sources based on LEDs and OLED are very versatile and adaptable to nearly any application, but on the other side they are much more sensitive to environmental operation conditions and challenging spectral measurements become indispensable. International comparisons, e.g. the IEA IC 2013 [1], show that measurement uncertainty is often underestimated in many testing laboratories. As a consequence, the International Commission on Illumination, CIE, developed the new standard CIE S025/E:2015 [2] for testing LED based lamps, modules and luminaires. This new standard necessitates the declaration of uncertainties even for test results. This is up to now unique for such test standards.

In this paper we will report on measurement techniques to improve the transfer of the units of photometric quantities to calibration laboratories and test laboratories. Examples are given showing the typical behaviour of LED lamps and OLEDs to underpin the need of the comprehensive characterization of the devices under test, of the references and of the measurement system to get satisfying uncertainties for measurement results of solid state lighting devices. Finally, also the realization of the photometric units needs to be reconsidered if the tungsten filament lamps typically used for the realization and distribution of the units are no longer available. First interim results on the improvement of the traceability chain for the photometric units at PTB are presented.

### Acknowledgement

This work was partly funded by the project “Metrology for Efficient and Safe Innovative Lighting” (MESaIL) of the European Metrology Research Programme (EMRP). The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

[1] 2013 IC Comparison Report; [http://ssl.iea-4e.org/files/otherfiles/0000/0067/IC2013\\_Final\\_Report\\_final\\_10.09.2014a.pdf](http://ssl.iea-4e.org/files/otherfiles/0000/0067/IC2013_Final_Report_final_10.09.2014a.pdf)

[2] CIE S 025/E:2015: Test Methods for LED Lamps, LED Luminaires and LED Modules

**Keywords:** LED, OLED, Reference, Testing, Calibration. Photometry



## New DC Thermometry Bridge Technology Design and Performance

**Richard Timmons, P.Eng., M.Sc.**

*President (Guildline Instruments, Smiths Falls, Ontario, Canada)*

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### **Abstract**

Direct Current Comparator (DCC) Bridges, despite their many advantages over their Alternating Current (AC) counterparts, have traditionally not been selected for primary thermometry applications. Rational for these decisions is that historically DCC Bridges have been optimized for higher power resistance measurements, lacked software designed for temperature applications, lacked thermometry accessories, and because AC Bridge technology typically provided faster measurements. Innovative design and performance techniques have been applied to the development of a new DCC Thermometry Bridge which provides improved performance and operational interface in comparison to AC temperature bridges and existing DCC temperature bridges. Many of these techniques have associated patents granted or pending. These techniques include:

- reducing the noise and improving the repeatability of temperature measurements by addressing fundamental limitations of the physics associated with the magnetic cores used in DCC bridges,
- increasing the ampere-turns of bridges to improve measurements with the low current levels required for thermometry,
- using a null detector rather than a resistor-divider network (i.e. sometimes called simulated windings) to provide additional resolution,
- applying the latest analogue design techniques and components to improve the null detector,
- decoupling the measurement rate from the polarity reversal rate in order to speed up measurements and provide more stable measurements,
- optimizing the tradeoff between digital filtering, latency, and measurement repeatability,
- using adaptive real time control and measurement algorithms to dynamically adjust to the measurement speed in accordance to the rate of temperature change,
- using techniques to speed up the time for a temperature measurement to stabilize,
- using the interchange technique to remove DCC bridge errors, and
- using a modern graphical user interface, and associated software, to improve real time analysis of temperature measurements.

Examples will be discussed with respect to the design techniques presented. In addition data will be presented and analyzed with respect to improved uncertainties versus traditional DCC and AC temperature bridges.

**Keywords:** Thermometry bridge, Temperature bridge, Direct current comparator, DCC, Temperature measurements

## Surface Enhanced Raman Spectroscopy in Molecular Detection, Diagnosis and Therapy

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*Quantum Phenomena & Applications*

*CSIR-National Physical Laboratory, Dr. K.S. Krishnan Road, New Delhi-110012*

(Email: ranjana@nplindia.org)

### **Abstract**

The application of plasmonics in the field of biomedical sciences has the potential to usher in a new direction of research and development. Nanoscale materials, being on a similar size scale as biological materials like DNA, lipids and proteins, can act as powerful research tools in biological sciences. A large number of applications include detection, bio sensing, cellular and *in situ* hybridization, cell tagging and sorting, diagnostics, kinetic and binding studies and cell imaging. Noble metal nanoparticles are especially interesting because of their unusual optical properties, which arise from their ability to support surface plasmons. Noble metals, especially gold, along with being biocompatible are relatively easy to synthesize and chemically functionalize. No toxic effect even at higher dosage is also an attractive property of these nanoparticles for *in vivo* imaging and therapeutic applications. Furthermore, gold nanoparticle based surface modification for protein immobilization is straightforward and is based on thiol chemistry.

Surface-enhanced Raman spectroscopy (SERS) is emerging as an important method for the characterization of biological materials. The limitation of Raman spectroscopy for bio-analyte detection is overcome in surface enhanced Raman Spectroscopy by exciting the sample in contact with a plasmonic surface with an appropriate laser line. In SERS, the signal intensity is extraordinarily increased, thus, enhancing the detection limits up to single molecule, while retaining all the structural information. For instance, gold nanoparticles can be used as a probe to detect multiple oligonucleotide targets with micro-SERS and different Raman dyes.

### **Keywords:**

## **Effective Utilization of Industrial Digital Pressure Gauges in International Comparisons**

**Tokihiko Kobata<sup>\*</sup>, Momoko Kojima and Hiroaki Kajikawa**

*National Metrology Institute of Japan (NMIJ)/  
National Institute of Advanced Industrial Science and Technology (AIST),  
(Research Institute for Engineering Measurement, Tsukuba, Japan)*

(\*E-mail : tokihiko.kobata@aist.go.jp)

### **Abstract**

Recently, characteristics of industrial digital pressure gauges have been improved remarkably. We focused on high-precision digital pressure gauges that were small, lightweight, as well as easy to handle, and engaged them in the world-leading development of transfer devices for international comparisons of standards. Using the developed transfer devices, several international comparisons have been carried out for promoting the international mutual recognition.

**Keywords:** Pressure standard, Digital pressure gauge, International comparison

## A Novel Approach Toward the Determination of E-mass by Differential Pressure Measurement

**A.K. Bandyopdhyay**

*Chief Scientist (Retd), CSIR-National Physical Laboratory, Dr. K. S. Krishnan Road,  
New Delhi-110012, India*

### Abstract

A watt balance is relatively simple in principle but the real challenge is to perform the experiment with a relative uncertainty in measurement of  $1 \times 10^{-8}$ . The hardest parts of the experiment are: (a) moving the coil in a strictly vertical line, (2) aligning the coil axis with gravity and the magnetic field at right angles to gravity. Existing Watt Balance experiments require correction systems, which add complexity and potentially introduce 'noise' to the system. MSL (New Zealand) [1] has developed a novel approach to overcoming these design problems.

A twine pressure balances is used as a mass comparator. As the differential pressure ( $\Delta p$ ) is directly related to differential mass ( $\Delta m$ ). The force generated by this  $\Delta m$  can be compensated by the utilization of an electromagnetic force which is generated by a moving coil in a magnetic field. In other words, as the coil is immersed in a horizontal magnetic flux, the current  $I$  in the coil exerts a vertical force on the conductor that is balanced against the weight ( $\Delta m$ ). There will be an equilibrium condition, that is, the force generated by the differential pressure (say upward) and electromagnetic force (say downward) and vice versa. Under this condition, the fall of the piston is sinusoidal with reference to the equilibrium condition. Under a typical balancing situation where the upward force is balanced by the downward force, the amplitude of the oscillation decreases as the downward force is trimmed by increasing the coil current under a constant magnetic field maintaining the same mass at the other side of the differential pressure balance. If the piston fall is measured by a laser interferometer and electromagnetic force by measuring the current and voltage as are done in the conventional Watt Balance technique that is, the calibration and measurement modes of operation, the same principle can be used. Under this condition, the coil is moved at a constant velocity  $v$  in the vertical direction through the flux and the voltage  $U$  induced across the coil and also in the calibration mode if the current  $I$  under the magnetic field  $B$  moves the coil velocity  $v$  :  $\Delta m = UI/gv$ . If we have a laser measuring system which can track the oscillatory motion of the coil with very high accuracy, we will get rid of the shortcoming of conventional Watt Balance where fall is at a constant speed. Pressure balances meet the key Watt balance requirements (a) means of moving coil straight and vertical as it is directly connected with a piston which moves in a well-defined axis and as a result the movement of the coil is almost vertical, (b) Floating element moves vertically within  $1 \Delta m$  over 10 mm (c) it is a weighing device of sensitivity with 1 part in 10<sup>8</sup>, (d) very low friction because of very narrow clearance less than 1  $\mu\text{m}$ ; (e) aerodynamic bearing with strong piston centring forces; finally, (f) no contact between piston-cylinder.

[1] Chris M Sutton, Measurement Standards Laboratory of New Zealand "MSL watt balance research: Status report to CCM Workshop on the mise en pratique of the new definition of the kilogram" 21 & 22 November 2012, BIPM, Sèvres, France.

**Keywords:** E-mass, Differential pressure, Twine pressure balance

## Metrological Equivalence, Traceability and Dissemination of National Pressure Standards and Some New Developments

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### Abstract

The national pressure standards established at NPL are mostly dead weight piston gauges. Piston gauge is a device that realizes pressure directly from the fundamental definition of the pressure and is often used as a primary / secondary pressure standard. Its main components are a piston-cylinder assembly and a weight. In order to keep pace with advancement in the field and cater the ever increasing demands of the industry and users for better and improved traceable pressure standards, NPL is also continuously focusing on to develop, establish and upgrade its pressure measurement capabilities. In recent past, NPL has established and characterized controlled clearance piston gauges (CCPGs) type primary hydraulic pressure standards in the pressure ranges of (10 - 100) MPa and (20 - 200) MPa. Most recently, our long efforts are resulted in to establishment of semi-automatic CCPG type primary pressure standards in the low pressure range (5 - 50) MPa and in high pressure range (50 - 500) MPa. These CCPGs are the unique systems being established at NPL having expected measurement uncertainties associated with effective area ( $A_0$ ) better than  $60 \times 10^{-6}$  at a coverage factor,  $k = 2$ . The system is also equipped with a reentrant type piston cylinder assembly of secondary pressure standard to cover low pressure range (1-10) MPa. We have also developed a twin post pressure balance type new facilities for the differential hydraulic pressure measurements up to 50 MPa, first time in India. The present paper describes the overview of the piston gauge type hydraulic pressure standards established at NPL over the years, their measurement traceability, existing calibration services, the CMCs registered in the Appendix 'C' of BIPM, recent results of the key comparisons and the progress towards new developments being carried out.

**Keywords:** Primary pressure standards; Controlled clearance piston gauge; Hydraulic differential pressure measurement

## An Overview of Fluid Flow Testing and Calibration Facilities at CSIR-National Physical Laboratory (NPLI)

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### Abstract

CSIR-National Physical Laboratory (NPLI) is the National Metrology Institute (NMI) for India and is responsible for establishment, maintenance, upgradation and dissemination of National Standards of Measurements except for ionizing radiations. The Fluid Flow Measurement Standard group at NPLI was formed in 1989 with the objective to establish, maintenance and upgrade the National Standards of Fluid Flow (gas and liquid) and to provide apex level testing and calibration services. The group has water meter testing facility up to 50 mm and it is being used to provide testing of Woltman type water meters as per IS 779, IS 6784 and ISO 4064 standards to the various user organizations traceable to the 'National Standards'. Initially, the Water Flow Calibration Facility at NPLI was established in joint collaboration with PTB, Germany during 1992 to 1998 under NPLI-PTB Technical Collaboration Program for calibration of different types of high accuracy water flow meters such as coriolis, ultrasonic, electromagnetic, differential pressure, etc. using static-gravimetric method as per ISO 4185. The facility was operational till 2001. The facility comprises of two test rigs, namely, DN50 and DN200 for calibration of water flowmeters of different sizes ranging from 10 mm to 200 mm. Both of the Test Rigs were revived during 2008 and 2009. As this old facility has traceability problem and also become obsolete due to technological advancement, therefore, its upgradation using state-of-the-art instrumentation and control was planned to improve our facility compatible to international level to maintain the NMI status in water flow area. As a follow-up of the upgradation and to develop capabilities for design and development of water flow calibration system, a prototype Water Flow Calibration System of size DN100 was designed and developed indigenously recently as per ISO 4185 standard. This is the low-cost solution to Indian industries as establishment of water flow calibration system requires huge funding. The expanded uncertainty of this prototype calibration system at 2000 kg and 1000 kg collected mass is  $\pm 0.03\%$  and  $\pm 0.05\%$  (at  $k=2$ ) respectively. This system is simpler and easy to maintain. Once the acquisition of the system is over, it would be used to provide traceable calibration and measurement services to the various user organizations in the country.

Keeping in view the requirement of in-house users such as Chemical Metrology group, Radio and Atmospheric Science Division, Solar Energy group, etc. and external users such as Pollution Control Boards, pharmaceutical industries, petrochemical industries, environmental monitoring equipment manufacturers, R&D laboratories, NABL accredited laboratories, gas flowmeters manufacturers, aerospace industries, etc., the Gas Flow Calibration System has been established recently which is based on laminar flow elements and sonic nozzles. The flow range of laminar flow element is from 10 sccm to 50 slm with operating pressure of 100 kPa absolute to 525 kPa absolute. The flow range of sonic nozzle (also called critical flow nozzle) is from 10 slm to 1000 slm with operating pressure of 50 kPa absolute to 525 kPa absolute. The expanded uncertainty of the Gas Flow Calibration System is  $\pm 0.2\%$  at  $k=2$  in the flow range of 10 sccm to 1000 slm. This system is being used for calibration of different types of flowmeters such as mass flow controllers, mass flow meters, rotameters, totalizer type meters (dry gas meters), digital flow calibrators, orifice flow calibrators, compact provers, etc. The system supports multi-gas calibration such as nitrogen, air, carbon dioxide, helium etc. In the present paper, an overview of NPLI fluid flow facilities has been presented.

**Keywords :** Uncertainty, National Metrology Institute (NMI), mass flow rate, volume flow rate, Water Flow Calibration Facility, Water Meter Testing Facility, Gas Flow Calibration System.

## **Leap Years, Leap Centuries and Leap Seconds : Less known Interesting Facts**

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### **Abstract**

The substantially higher accuracy of the atomic clocks introduced from the 1960s has enabled one to measure the fluctuations and a gradual slowing down of the rotational speed of the Earth. The leap second correction was introduced in 1972 to make the atomic clock based time to be in synchronism with the Sun based time. While the Y2K problem of 2000 was avoided by the robust professional programs, when the leap second correction was made on 30 June 2012 many WEB based systems had problems, the most dramatic being the 5 hour crash of the QANTAS Airline Reservation System. Major social dislocations were present when Julius Caesar introduced the Leap Year in 46 B.C. and when Pope Gregory XIII introduced the Leap Century in 1582 A.D. Modern research has thrown doubts about even the date and year of the birth of Jesus Christ. Currently the matters connected with the leap second corrections are under discussions and the present scenario will be summarised.

**Keywords:** Atom clock, Y2K Problem, Leap Year, Leap century

## NIM, Today and in Future

Wu Fangdi

*NIM, China*

### Abstract

**What is NIM :** Founded in 1955, the National Institute of Metrology (NIM) is a non-profit research organization under the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ). It is China's national metrology institute (NMI) and the state-level technical center for legal metrology. It is China's signatory to the CIPM MRA and a full member of the APMP. It stays at the top of China's traceability chain.

### History

- 1955: NIM was founded
- 1970: a sub-institute of NIM was founded, which later become the National Institute of Measurement and Testing Technology (NIMTT) at Sichuan Province
- 1989: the National Research Center for Certified Reference Materials (NRCCRM) was independent of NIM
- 1998: the State Council approved NIM to build a new campus at Changping district of Beijing
- 2005: NRCCRM merged into NIM, marking the birth of new NIM that covers metrology both in general physics and chemistry
- 2009: The Changping campus was put into service

**Technical Capabilities :** As of March 2015, NIM maintains 130 national primary standards, 296 national standards and provides 1270 types of certified reference materials. NIM has 1224 calibration and measurement capabilities (CMCs) published in the BIPM KCDB. NIM provides 587 AQSIQ-authorized verification services, 568 CNAS (Chinese national laboratory accreditation body) accredited calibration services and 335 testing services.

**Research :** NIM is committed to pushing back the frontiers of metrology science to support economic and social development of China. Since 2006, the beginning of the 11<sup>th</sup> "Five-Year Plan" period of China, Chinese Government has significantly increased its funding for research. Based on metrology science development and national needs, NIM has identified two major research directions: (1) SI redefinition and development of advanced quantum standards, and (2) emerging priority fields, including new energy, advanced materials and nano-metrology, biological measurement, environmental measurement, medical measurement, and metrology for the new-generation IT metrology. A number of new laboratories were built in the Changping Campus.

**Vision :** To promote industrial competitiveness and underpin the economic and social development of the country with world-advanced science, standards and measurement capabilities.



## **Increasing Sensitivity of Experimental Techniques Leads to New Insights : *High Resolution X-ray Diffraction Experiments***

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### **Abstract**

In physical sciences there is an unending endeavour to take the sensitivity of measurements to limits X-ray diffraction is a unique area of science where normal experiments are performed at a resolution level that is a hundred to thousand times lower than the ideal condition. The author and his collaborators have learned that a push in the sensitivity of experimental techniques has led to deeper understanding of physical phenomena and new facts could be revealed. In this presentation a few examples will be presented which illustrate this point.

The dynamical theory of diffraction is the most rigorous theory of X-ray diffraction. The theory assumes the specimen crystal to be nearly perfect and 'thick' defined as  $t \geq 10$ . It predicts that the half widths of diffraction maxima will be of a few arc sec and the reflectivity will be close to 100 % in reflection geometry. Also, two diffracted beams are expected in transmission geometry One needs a highly collimated X-ray beam with divergence of below 1 arc sec and wave length spread of about  $10^{-5}$ . A variety of high resolution X-ray diffractometers had been developed in author's laboratory. The most sophisticated among them is a Five Crystal X-ray Diffractometer with state-of-the-art level resolution. Experiments at highest resolution had given several results of considerable fundamental importance and of value in applications. A systematic study of diffuse X-ray scattering very close to the diffraction maxima established that at and near room temperature the scattering is primarily due to defects and not due to thermal vibrations of crystal lattices as was considered until this work. This technique enables non-destructive characterization of point defects and their clusters and is now often referred to as reciprocal lattice mapping. For example in silicon crystals it could correlate crystalline perfection with oxygen content. In implanted crystals it has demonstrated the segregation of implanted impurities. It has led to discovering a new defect, named as 'very' low angle boundary with tilt angles as low as a quarter of a arc minute For the first time electric field induced microstructural changes could be directly observed in semiconductors and insulators. In-depth investigations of MBE grown thin epitaxial layers demonstrated the presence of an orientational mis-match in addition to the usual lattice match. An accurate technique of determining biaxial stress has demonstrated that initial bending of substrates must be taken into account otherwise the value of stress as well as its sense will become questionable. Dynamical diffraction effects like the presence of a forward diffracted X-ray beam and a loss in absorption could be directly observed with 'thin' diamond crystals ( $t \ll 1$ ) of varying degrees of perfection. Recently it has been possible to image a few nanometer thick layers on silicon crystals by high resolution X-ray reflection technique.

### **Keywords:**

## Multi Sensor Data Fusion in Mobile Robots

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### **Abstract**

An important and useful feature of autonomous mobile robots is their ability to adopt themselves to operate in unstructured environment. Modern robots are performing autonomously in industrial floor, office environments, as well as in domestic environment where the robots need to maintain a model of their surrounding environment. The acquired knowledge of an environment through learning process is used to build an internal representation. To attain such type of knowledge, robots must possess sensors that enable them to perceive the outside world. There are several sensor modalities commonly brought to bear for this task such as ultrasonic, laser range finders, radar, vision and infrared, etc. However, most robot sensors are subjected to strict range limitations and errors often referred as measurement noise. From the last two decade, multisensor data fusion in mobile robots has become a dominant paradigm due to its potential advantages like reduction in uncertainty, increase in accuracy and reliability and reduction of cost. Sensors play fundamental role in mobile robot mapping. It is the process of generating models of a mobile robot's environment based on sensory information with an aim to determine the location of various entities such as landmarks or obstacles. An accurate model of the environment is needed so that a robot completes complex tasks with high reliability and efficiency. Without such a model, a robot neither can plan a path nor effectively search for an object or place. The mapping problem is generally regarded as one of the most important problems in the pursuit of building truly autonomous mobile robots. Despite significant progress in this area, it still poses great challenge such as robustness in map. A new architecture of sensor fusion framework is developed to make the map robust and reliable. The qualitative comparisons show the improvement in the results where the overall occupied and empty area of the resultant map is extremely near to the reference map.

**Keywords:** Fusion framework Mobile robots

## **Needs and Challenges in Nanometrology: Role of National Measurement Institute**

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### **Abstract**

Nanoscience, Nanotechnology and Nanometrology areas have open up a new world in the field of science due to its vast importance in today's world. In this paper we will discuss about the need of nanometrology (the science of measurement and its application at nanoscale) and challenges and opportunities therein. Furthermore we will discuss about the role of 'National Measurement Institute' (NMI), to tackle these situation, in view of the demands of nanoscience and technology measurements in the country. In the end of this paper, in brief, we shall discuss the status of nanometrology at NPL-I, the task of establishing the traceability infrastructure for nanometrology of few of the parameters. At first instance. facilities which have been established at NPL-I for providing traceability are namely: line width, step height, surface texture measurement in the field of nano dimension measurements; as well as for calibration of low voltage (nV), low current (pA), low resistance ( $\mu\Omega$ ) and electric charge (nC), at the low level electric measurements.

**Keywords:** Nanoscience, Nanotechnology and Nanometrology

## Critical role of Nanometrology in Biological and Medical Sciences

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### Abstract

The science of measurement at the nanoscale is called Nanometrology. The ability to measure and characterize materials which determine their size, shape and physical properties at the nanoscale is vital if nanomaterials and nanodevices are to be produced to a high degree of accuracy and dependability. It is well known that at nanoscale, the properties of materials are prone and very sensitive to the diameter of their nanoparticles. Hence, designing and manufacturing of nanoparticles with singular and specific diameter are of crucial importance for nanodevices, specifically in health care industries. In view of this, the field of Nanobiotechnology cannot progress independently without progress in Nanometrology. Nanometrology includes measurements where dimensions are typically between 100 nm and includes measurements of force, mass, electrical, magnetic and other properties. If techniques for making these measurements are advanced, then one can understand nanoscale behavior of materials. The instruments for making such measurements are many and varied. The applications of Nanometrology in medical sciences such as drug delivery, bacteria detection and capturing, magnetic hyperthermia, repairing of bones, implant of soft tissues, artificial tooth development and cavity repair are important biomedical applications where in the greater control on nanoscale is required. In addition to this, the emphasis will be given to highlight the work carried out in the “Centre for Interdisciplinary Research”, D.Y.Patil University, Kolhapur.

**Keywords:** Nanometrology, Nanoparticles, Drug and bacteria

## **Dimensional Nanometrology: Needs, Challenges and Status at NPL India**

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### **Abstract**

Nanometrology is still an emerging area in field of metrology. Recent trends of miniaturization in manufacturing and rapid growth of nanoscience and nanotechnology has led to the concern for nanometrology. Nanometrology encompasses metrology at nanoscale in various measurement areas and thus there are fields within nanometrology e.g. Nanooptics metrology, Nano-dimension metrology, nano chemical metrology, nano electrical metrology and soon. Nano-dimension metrology is important as it underpins the developments in miniaturization in various areas of manufacturing like automobile sector, semiconductors, thin films and surfaces. Nano-dimension metrology also is an essential part in some of other areas of nanometrology e.g, mechanical properties such as hardness, and other measurements / properties dependent on size.

The need for metrology is as essential to nanotechnology related product as in classical products. For quality assurance in nanotechnology, one has to demonstrate that the products and manufacturing process meet demanded specifications. This requires quantitative measurements traceable to common standards. Nano-metrology is not only a matter of change of scale of measurements, but it is matter of change of underlying physics also, for example Casimir forces may become relevant at nanoscale. Thus Challenges of nanometrology are unique. International workings groups have been working to identify needs, & challenges and make work programs for nano-dimensional metrology.

At NPL India we have made a modest beginning by setting up traceable measurements infrastructure in nanometrology. In case of Nano dimension measurements we have setup traceable facilities for step height measurements, Surface texture measurements and line spacing measurements. A metrological atomic force microscope with integrated laser interferometers for x,y,z scale measurements and a 3D optical profiler have been established. In this paper we shall discuss needs and challenges in nano- dimension metrology and also present the present status of nano-dimension metrology capability at NPL India.

### **Keywords:**

## Realization of Mole under Metrology in Chemistry Activity: Current Status and Future Plan

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### Abstract

The mole, symbol mol, is the SI unit of amount of substance of a specified elementary entity, which may be an atom, molecule, ion, electron, any other particle or a specified group of such particles; its magnitude is set by fixing the numerical value of the Avogadro constant  $N_A$  to be  $6.022\,141\,29 \times 10^{23}$  when expressed in the SI unit  $\text{mol}^{-1}$ . In other words, the number of entities in one mole is equal to the numerical value of the Avogadro constant, which is known as the Avogadro number. This definition was agreed for the planned 26<sup>th</sup> CGPM in 2018. It may replace the definition agreed in 1971, which defined the mole as the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12. In practice, the uncertainty in primary realization of mole differs from methods generally used to realize the mole. In metrology in chemistry, the realization of mole in all types of chemical entities is done using variety of primary methods of measurements in terms of the amount of substance concentration ( $\text{mol}/\text{m}^3$ ), amount of substance content ( $\text{mole}/\text{kg}$ ) or amount of substance fraction ( $\text{mol}/\text{mol}$ ). Three widely used methods to realize the mole are: gravimetric, use of the ideal gas law and electrolysis. Currently for the realization of mole, a network project on the "International Avogadro Coordination" is formulated in which few NMIs are jointly working to determining the best experiment values of both the Avogadro and Planck constants prior to fixing their current values. Other than this constant, in practice the dissemination of traceability (of mole measurement/ realization) in metrology in chemistry is done by an artefact (e.g. in the case of ozone measurement) and using certified reference materials (this is a widely used practice in chemistry). At CSIR-NPL, our focus is to prepare elemental calibration solutions and primary gas standards (especially for greenhouse gases, and criteria pollution gases and particulate matter). We have our network partners in different sister laboratories of CSIR those involved in preparation of CRMs in water, food material, etc. Also, we have a joint technical cooperation project with PTB, Germany for supporting this activity in India. Recently, NABL with the cooperation of CSIR-NPL has also started a "Reference Material Producer (RMP)" program in India in which they are giving accreditation to RMPs. Beside this there are so many challenges in this area as it is directly linked with quality of life. This talk will be focused on such issues and future plan of MiC activity at CSIR-NPL.

**Keywords:** Mole realization, MiC, International-national status, Challenges, Future plan.

## **Agriculture Crop Residue Burning in Indo Gangatic Plains : A Global Threat**

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### **Abstract**

From few decades, the intense burning of agricultural waste is being considered as burden for atmospheric environment on global scale. This activity releases a huge amount of hazardous gases and respirable suspended particulate matters into ambient environment, which are responsible of mortality and morbidity. As per WHO reports, they cause several chronic diseases like asthma, shortness of breath etc. From several satellites based studies and research activities it has been observed that the Indo Gangatic plain areas like Punjab, Haryana, Utter Pradesh are the key regions where agriculture waste fire counts were more than other regions. Due to high yield crop seeds and modernisation in harvesting process, every year 27 million tonnes (approx.) of crop residue waste generated and burnt in this belt. Despite the legislative acts and policies, the fire counts were intense in few peak months (October -November and March April). It has been observed in literature survey that there are veryfew ground based studieswho evaluated the health status of living beings in these regions. To evaluate the health level of inhabitants, a study was conducted in Punjab region. We randomly select 150 healthy children from different cities of Punjab. Spirometric tests were conducted on selected children for minimum four crop burning seasons. The results were alarming. During and after burning episodes, a fall was observed in various respiration related parameters which were statistically significant when related to pollutant levels like  $PM_{10}$  and  $PM_{2.5}$ . It has been seen that the maximum degradation was observed in capacity and flow of lungs. From the research it can be concluded that the physiological parameters were very sensitive to the raised levels of pollutants than the permitted levels. It has been seen that the agriculture crop residue burning affect the carbon credits of South East Asia. From the trends and ground reality it can be concluded that this practice is very harmful for local and regional level. This practice not only affects the ambient environment but also the health level of human subjects. With the exponential growth in agriculture field, it can be predicted that the trends are likely to be more adverse in future. There are various methods to handle the agriculture waste like use for energy generation, as fodder for cattle, as fertilizer etc. So strong legislative steps should be taken in the areas to stop this practice, otherwise results will be chronic.

**Keywords:** Agriculture crop residue burning, Pollution levels, Respiratory parameters, Health of children, Indo Gangatic Plains

## **International Magnetic Standards on Electrical Steel to Hydroelectric Cell as Green Energy Solution.**

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### **Abstract**

Primary standard laboratory at NPL for advanced primary standards on magnetic measurements was established further extending the work for a low magnetic field range (100 $\mu$ T to 2000  $\mu$ T with an uncertainty  $10^{-4}$ ). Recently on Jan 8, 2012 this lab has been internationally recognized for 10 magnetic measurements parameters in the preview of ISO:17025 for International Bureau of Weights & Measure, (BIPM) France. It certifies that these parameters capability is comparable to the best in the world and certificates. It includes electrical steel power loss measurements by IEC-404.2 international standard test.

In this talk primary standards on magnetic measurements have been elaborated and especially international standard on electrical steel power loss measurements (used for transformer, motor and generator cores) has been outlined. Regulating this test on distribution transformer very effectively shall save a huge power loss from the transformers.

After long persistent & consistent efforts a green electrical energy source has been innovated as - Hydroelectric Cell based on water molecule dissociation at room temperature by Lithium substituted Magnesium Ferrite. Hydroelectric Cell is a combination of materials property with electrode reduction potential, not reported by anyone. Nano pores created in magnesium ferrite develop enough electric field so that physisorbed water molecule is dissociated spontaneously into ions to generate electric power of 82 mW. The process is physical phenomenon of material followed by ions collection. This work is based on porous Lithium substituted magnesium ferrite material property for the first time to dissociate water molecule at room temperature and we have exploited collection of hydrogen & hydroxide ions using electrode reduction potential of zinc & silver in large quantity continuously. Its working principle has been elucidated in this talk.

**Keywords:** Magnetic standard, Hydro electric cell



## **LF, HF Impedance & DC Standards at CSIR-NPL: Present Status**

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### **Abstract**

The LF, HF Impedance & DC standards at CSIR-NPL is concerned with the realization, up-gradation, maintenance and dissemination of primary standards of capacitance, inductance, resistance (both DC & AC) and DC voltage to provide highest level of precision calibration facilities to the various regional calibration and testing laboratories and other organizations and industries of the country providing traceability to the SI units. In this presentation we shall provide an overview of the present capabilities at CSIR-NPL in this area. The presentation will also cover the in-house developmental activities directed towards upgrading the present capabilities.

### **Keywords:**

## **Importance of NMIs Participation in BIPM Key/ Supplementary Inter-comparisons**

**P. S. Negi**

*LF & HF Voltage, Current and Microwave Standards  
ALSIM-NPL, New Delhi*

### **Abstract**

The Regional Metrology Organizations (RMOs) of Bureau of Weights and Measures (BIPM) play an important role in the CIPM Mutual Recognition Arrangement (MRA) and also has the responsibility for carrying out comparisons to support mutual confidence in the validity of the calibration and measurement certificates of their member National Metrology Institutes (NMIs). The NMIs through CIPM MRA demonstrate the international equivalence of their measurement standards and the calibration and measurement certificates they issue. The result is internationally recognized (peer-reviewed and approved) Calibration and Measurement Capabilities (CMCs) of the participating institutes. The Consultative Committee (CC) of the CIPM selects the key quantity to be compared, approves the protocol of the comparison, and the results before publication in the Key Comparison Data Base (KCDB). The comparison can be CIPM of international scope delivering a reference value for the chosen key quantity or RMO of regional scope with a number of common participants and with protocols allowing their results to be linked to those of the CC key comparison.

As a Sub-Division of ALSIM-NPL (NMI India) our activity has the responsibility to establish, maintain and upgrade the present apex level standards and related calibration facilities for LF & HF Voltage, Current and Microwave parameters and to continuously participate in BIPM/ APMP inter-comparisons to establish a close degree of equivalence in measurements among the participating NMIs. ALSIM-NPL India has participated in many comparisons in the past and demonstrated its capability to Initiate & Pilot APMP comparisons in Electrical and Physico-Mechanical parameters. We share our experiences in the recently piloted APMP comparisons for AC and microwave parameters.

### **Keywords:**

## **Present Status and Future Plan of AC High Voltage and High Current Standards at CSIR-NPL**

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*Apex Level Standards and Industrial Metrology*

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### **Abstract**

AC High Voltage and High Current Standards of NPLI is maintaining National Standards for AC High Voltage (HV) and High Current Ratios at power frequencies (50Hz) by using Reference Standard High Voltage Ratio Measuring System (upto 100kV) and Reference Standard Current Transformers (upto 5kA), respectively. It is also maintaining the National Standards for the calibration and measurement of AC HV Capacitance and  $\tan \delta$  upto 200kV at 50Hz by using Reference Standard HV Capacitors and High Precision C &  $\tan \delta$  Measuring System. This activity is disseminating the traceability at par with international level for voltage transformers, current transformers, HV capacitors, HV capacitance bridges and allied equipments.

It is planned to enhance the facilities of AC high voltage upto 300kV in recent times and upto 765 kV in future, to meet the needs of the power sector industries and utilities. Similarly, the high current facilities are also planned to be enhanced from 5kA to 20kA. The present status and future plan of various parameters in this activity, along with their traceability and uncertainty in measurements will be presented in detail.

**Keywords:** AC High Voltage, AC High Current, Current and Voltage Transformers

## Recent progress in quantum Hall effect resistance metrology

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### Abstract

The quantum Hall effect (QHE), which is a fundamental characteristic of high mobility 2DEG systems was discovered by K von Klitzing [Phys. Rev. Lett. 45, 494 (1980)]. QHE provides an invariant reference for resistance linked to fundamental constants  $e$  and  $h$  ( $R_H = h/ie^2 = R_K/i$ ). The quantized resistance given by  $R_K = h/e^2 = 25812.807557(18) \Omega$  is called the von Klitzing constant [Rep. Prog. Phys. 64, 1603 (2001), Phil. Trans. R. Soc. A 363, 2221 (2005), Phil. Trans. R. Soc. A 369, 3954 (2011)]. The QHE (at 1.3 K and a magnetic field of 5-14 T) supplies a quantum resistance standard of value  $R_K/i$  ( $i=2$ ), with a relative reproducibility better than  $10^{-10}$ . The bridge used for comparison of resistance standards is either cryogenic current comparator (CCC, operating at 4.2 K) or a room temperature direct current comparator (DCC); the former having much better accuracy (uncertainty  $\sim 10^{-9}$  in terms of  $R_{K-90}$ ). The most widely QHE device is the GaAs/AlGaAs quantum well. Current state of the art in carrier mobility for ultralow disorder in GaAs/AlGaAs system is  $35 \times 10^6 \text{ cm}^2/\text{Vs}$  [J. Cryst. Growth 311, 1658 (2009)]. In recent years several other new 2DEG systems have emerged. Among the new 2DEG systems, Graphene has stolen all the lime light ever since its discovery in 2004. After the first demonstration of QHE in graphene [Science 315, 1379 (2007)], NPL-UK took the lead and made the first demonstration of the quantum Hall effect in Graphene in quantum resistance metrology [Nature Nanotechnology 5, 186 (2010), New J. Phys. 13, 093026 (2011), Metrologia 49, 294 (2012)]. The most recent report (LNE-France) in this direction [Nature Nanotechnology 10, 965 (2015)] clearly establishes the applicability of Graphene based devices in quantum resistance metrology. The agreement between quantized Hall resistance in Graphene and GaAs/AlGaAs with an ultimate relative uncertainty of  $8.2 \times 10^{-11}$  [Nature Communications 6, 1 (2015)] is also very encouraging. Recently, 2DEG showing the integer and fractional QHE has also been realized in  $\text{ZnO}/\text{Mg}_x\text{Zn}_{1-x}\text{O}$  hetero-interface [Science 315, 1388 (2007), Nat. Mater. 9, 889 (2010), Phys. Rev. B. 89, 075307 (2014)].

### Keywords:

## Time and Frequency Metrology at NPL India

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### Abstract

Atomic Clocks of NPL have the prime responsibility of maintaining the Indian Standard Time (IST). The atomic clocks provide a standard against which all the time and frequency signals in the country are mandated to be calibrated. This internationally accepted standard provides the most precise reference standard to the society for their timing applications in precision navigation, location determination, mobile and broadband telecommunication, Bank and Stock market transactions, Flights and aviation, Power distribution, automated traffic signaling system and many more. In the recent years, NPL has started contributing to the development of Indian Regional Navigational Satellite System (IRNSS) by developing atomic clocks suited to be operated in space. Further time scale of IRNSS is being provided traceability to the Coordinated Universal Time (known as UTC) by NPL, wherein even billionths of a second are significant. The accurate timings signals generated by atomic clocks are also used to develop various national primary standards such as those of length and voltage.

NPL has indigenously developed a new atomic clock, the cesium fountain, based on control of atomic motion using laser cooling and trapping of atoms. This has led to the most accurate measurement of frequency in the country. The cesium fountain frequency is stable to few parts in  $10^{15}$  at less than one day of averaging time and realize the second of the international system of units. The fountain is now contributing to calculation of the international timescales, UTC (Coordinated Universal Time) and TAI (International Atomic Time). NPL is in process of developing an improved version of the current cesium fountain.

NPL has also started working on an atomic clock based on an optical transition of a single trapped  $^{171}\text{Yb}^+$  ion. Accuracy of such a clock is expected to be two orders of magnitude higher than the fountain clock, since the operational frequency is about ten thousand times larger than that of the fountain clock.

### Keywords:

## Mass Determination in Legal Metrology

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### Abstract

Mass measurement should be looked from two angles: first of all its importance lies in being one of the base units. Here is scientific metrology in mass is involved. Secondly, mass measurement is an important parameter in industry and trade and finally falls under the preview of legal metrology, so subjected to certain mandatory controls.

Mass measurement in scientific metrology way and legal metrology is carried out on basis of OIML (the International Organization of Legal Metrology) Recommendation R-111. Most of the NMI's (National Metrology Institutes) follow R 111-1: 2004 standard for mass determination. The other standard for mass determination is ASTM E617: 2013. This is also broadly based on OIML R 111-1: 2004. The standard OIML R 111-1 covers every aspect of the verification and criterion of weight of nominal values from 500 kg to 1 mg and covering all classes.

Mass measurement from scientific angles has nine classes of weights, E1, E2, F1, F2, M1, M1-2, M2, M2-3 and M3 according to their maximum permissible error (MPE).

Mass measurement from legal metrology angle has three classes namely, 1) reference standard weights, 2) Secondary standard weights, 3) Working standards weights.

In this paper, we elaborate discuss the MPE of different classes of weights as per OIML R-111-1 legal metrology weights as per Legal Metrology Act 2009, which came in effective from 1<sup>st</sup> April 2011.

Author will also throw some light on special type of weights under Indian Regulation like carat weights, flat cylindrical weights, hexagonal weights etc.

**Keywords:** Mass measurement, OIML, R 111-1: 2004.

## Facilities Established at CSIR-NPL for the Realization and Dissemination of Force, Torque and Hardness Measurements

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### Abstract

CSIR-National Physical Laboratory, India is the National Measurement Institute (NMI) of India, which has been the custodian of national standards in India at apex level which also disseminates the national standards to the users including strategic sectors, calibration laboratories and various industries. Precision measurements of Force, torque and hardness are very much essential to several mechanical industries like automobile, aviation, etc. and for testing of materials under stress which involves compressive and tensile forces.

This group has been actively involved in establishing the primary standards, at par with other internationally reputed NMIs, for realizing the scales of force, torque and hardness in order to provide the necessary traceability to the user industries across the country. This group is also constantly engaged in research and developmental activity for augmenting and upgrading the capability of the machines to keep abreast with the changes taking place in the international standards and also equips itself to participate in the international inter-comparisons to establish equivalence of the standards to the international system of measurements.

We have established facilities for realizing these derived parameters based on the first principle method according to the requirements of international standards at national level and maintain them to their best possible performance. For the realization of force in range of 1 N – 3 MN, many standard machines have been used having different measurement capabilities. A force standard machine (FSM) of 1 MN capacity is established at CSIR-NPL to provide precise measurement of force in range of 1 kN – 1 MN which is serving as the primary standard for force and from which other force calibration machines such as dead weight force machine (DWF), dead weight cum hydraulic/ lever multiplication machine and force comparator machines derive their traceability. This machine consists of a deadweight part to generate a nominal force of 100 kN capacity and a lever amplification part with a nominal force of 1 MN. The uncertainty associated with the realized forces is  $\pm 0.002\%$  ( $k=2$ ) for the dead weight side and  $\pm 0.009\%$  ( $k=2$ ) for lever multiplication side of the machine which was reaffirmed through a bilateral comparison with the PTB, Germany.

A primary torque standard machine has been established in our lab for realizing torque in the range of 2-2000 Nm, consisting of a double sided lever supported on strain controlled elastic hinges, having a best measurement capability (BMC) of  $\pm 0.01\%$  in this range. The established BMC of the machine was reaffirmed by participating in the CCM TK1.1 inter-national key comparison and this primary machine is used to provide the traceability in torque measurement to the other torque machine comprises of a lever balanced on device axis and calibrated dead weights to generate torque in the range of 20-2000Nm and also to the user industries.

Hardness standardizing machines are established for the precision measurements of hardness values in the Brinell, Vickers and Rockwell scales as per the requirements of the international standards. The CMC values of these machines are reaffirmed by comparing the realized hardness values using high precision standard hardness blocks having traceability to a leading NMI. The CMC values in HRA and HRB scales are also reaffirmed in APMP key comparison. In this presentation, we will discuss about some of the salient features of these machines, the inter-comparison results, the impact of the precision measurements in traceability and the influence of such measurements in the industrial growth.

**Keywords:** BMC, CCM TK1.1, Hardness, Force





**POSTER**



## **Thermoelectric Technology : An Overview on Fundamental Theory to Physical Measurement**

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### **Abstract**

Thermoelectric research has witnessed ground breaking progress over the past few decades. Improvement in the thermoelectric figure of merit,  $ZT$ , a measure of the competition between electronic transport (i.e. power factor) and thermal transport (i.e. total thermal conductivity) has long been surpassed long time barrier of  $\sim 1$ . Technology that was once considered too inefficient to be cost effective, is now looked as a potential technology for future and thermoelectric scientists are targeting  $ZT > 2$  as the new goal.

Development activity of thermoelectric materials at CSIR-National Physical Laboratory (NPL) focuses on the mid to high temperature range (i.e. RT to 900°C). An extensive spectrum of measuring techniques (temperature dependence of the Seebeck coefficient, thermal and electrical conductivity, Hall coefficient and thermoelectric figure of merit) is required for comprehensive functional characterization and transport properties analysis in thermoelectric materials, which involves a wide temperature range spanning from ambient up to highest relevant temperatures. This article discusses an overview of fundamental theory to physical measurement used in thermoelectric analysis. Real thermoelectric material properties are highly temperature dependent and are often measured individually using multiple measurement tools on different samples resulting in large uncertainties in the reported  $ZT$  values.

**Keywords:** Thermoelectric, Measurement Techniques, CSIR-NPL,

## Preparation of Primary Gas Standard Mixture of Carbon Monoxide in Nitrogen by Gravimetric Method

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### Abstract

Carbon monoxide (CO) gas is emitted to the atmosphere from the incomplete combustion of fuels and carbonaceous material, such as crude oil and petroleum products, wood, coal, charcoal, trashes, etc. It is toxic to hemoglobin animals and humans. According to Occupational Safety and Health Administration (OSHA), the maximum allowable concentration, i.e. time weighted average (TWA) permissible exposure limit (PEL) of CO for continuous exposure in any 8-hour period is 35 ppm (40 mg/m<sup>3</sup>). When encountered in concentration above about 35 ppm, it combines with hemoglobin with an affinity ranging from 210 to 240 times greater than that of oxygen to produce carboxyhemoglobin, which usurps the space in hemoglobin that normally carries oxygen. The natural concentration of carbon monoxide in air is around 0.2 ppm, however it varies with site depending on the sources at the sites. Therefore it is an important criteria pollutant of many national ambient air quality standards (NAAQS). Analyzers based on several adequate techniques (e.g. NDIR/GFC, CRDS, etc.) exist for highly reliable monitoring of CO to ensure compliance with the NAAQS. Gas chromatography technique is also used for semi-continuous monitoring or off-line measurements. For reliable measurement, it is essentially required that instrument is calibrated using SI traceable gas standards. Therefore, in this paper we discuss about the preparation of gas mixture of CO in N<sub>2</sub> at National Physical Laboratory India (NPLI) facility. These mixtures are prepared gravimetrically in accordance with ISO 6142 "Gas analysis-Preparation of calibration gas mixtures-Gravimetric method". Two sets of the CO gas mixtures at a nominal concentration of 87 - 113 μmol.mol<sup>-1</sup> are prepared. Each set consists of 3 dilution steps in a series starting from pure CO (99.97%) and targeting to the mole fractions of 5/95, 0.25/99.75 and 0.01/99.99, respectively. The cylinders used were made up of aluminium having a pressure of approximately 120 bar and volume of 5 dm<sup>3</sup>. All the weighing of the gas cylinders was done using equal arm double pan balance with the precision of 1 mg in 25 kg. Further, the analysis of the impurities in the diluent gas (especially CO, CO<sub>2</sub> and CH<sub>4</sub>) was determined using CRDS and GC techniques. Prepared standards are validated/tested against SI traceable standard using GC-FID technique in accordance with ISO Guide 34.

**Keywords:** Carbon monoxide, Primary gas standard mixture, Gravimetric method

## **Two Rules based Fuzzy Swing-up and Four Rules based Non-linear Fuzzy Stabilization of Rotary inverted Pendulum and Comparison with Linear Fuzzy Controller and LQR**

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### **Abstract**

The application of fuzzy control to large-scale complex systems is not, by no means, trouble-free. For such systems the number of the fuzzy IF-THEN rules as the number of sensory variables increase, increases very quickly to an unmanageable level. When we take into account more input variables in control system, the number of rules grows exponentially, if we have  $l$  possible values for each of  $n$  variables, we must describe control corresponding to all  $l^n$  possible combinations of input variables. In this paper, Swing-up and Stabilization of the Rotary inverted pendulum (RIP) is done through the fuzzy controller. The attraction of this paper is achieving the above stated aim through lesser number of rules. RIP is highly unstable and nonlinear in nature, so stabilization of the RIP is itself a challenging task. Swing-up mechanism in RIP is a type of unstable mechanism which is done effectively by using a fuzzy controller only, by just two rules. There are four states of RIP that needs to be controlled and they are controlled by fuzzy controller with the help of only four rules. Fusion technique has been applied to reduce the number of inputs of the fuzzy controller so that the fuzzy controllers which have less number of rules can also be applied on complex systems. Simulation which is done on MATLAB/SIMULINK shows the effectiveness of the proposed controller and its implementation, successfully in real time.

**Keywords:** Swing-up fuzzy, Stabilization fuzzy, RIP

## Dispersivity: A New Parameter for the Ultrasonic Metrological Characterization of Liquids

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### Abstract

The velocity at which an ultrasonic wave propagates through a medium and the amount by which it is attenuated are governed by interactions between the ultrasonic wave and the medium particles. The parameters responsible for such interactions are attenuation and dispersion. Till now ultrasonic attenuation was the only parameter to act as a probing tool for assessing losses occurring in the medium due to propagation of ultrasonic waves. Attenuation is not an absolute but relative parameter and hence includes measurement errors. The reported values for these measurement errors available in literature vary among different studies. The alternate approach is to measure dispersion instead of attenuation. The measurement accuracy improves in the dispersion measurement because velocity estimation is fundamentally a time based measurement, while attenuation estimation is a voltage based measurement. Furthermore, the use of advance instrumentation and state of art electronics results in detection of even a small quantity of dispersion, which was not possible earlier as its value is comparable to experimental uncertainty. To quantify dispersion, higher accuracy in measurements is expected with dispersivity as it is a time based measurement.

In this paper, we introduce a new parameter namely *Dispersivity*, with the aim to explore the high frequency sound dispersion in liquids. Experiments are conducted for the measurement of ultrasonic phase velocity as a function of frequency in several liquids and liquid mixtures. We carry out dispersion measurements in a series of liquids/mixtures. The maximum estimated uncertainty is found to be  $\pm 0.02\%$ . Water showed minimum dispersivity of 5%, which earlier supposed to be having dispersion less. Binary mixture of ethylene glycol showed a maximum dispersivity of 28%. The results thus obtained are on the dispersivity measurements in these liquids are discussed in details.

This work could find potential applications in the development of ultrasonic spectroscopy as a characterization tool. Further studies are required to explore the possibilities of its applications in the fields of ultrasonic metrology as reference liquids for intercomparison exercises and in non-destructive testing (NDT).

**Keywords:** Metrology, Dispersion, Ultrasonic, Liquids, Uncertainty.

## Measurements of Shear Strength of High Strength Reinforced Concrete Beams

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### Abstract

Measurements were carried out to study the shear behavior of high strength reinforced concrete beams without web reinforcement. Comparison of the experimental results with various available data and the shear models has been made. The effect of shear span to depth ratio ( $a/d=2.4$ ) and compressive strength of concrete (M60, M80) with different percentage of longitudinal reinforcement (0.66%, 1.04%, 1.32%, 1.5%, 2.08% and 3%) on the shear strength was investigated. The study has revealed that there is a great impact of longitudinal reinforcement on the shear strength of the beams. The experimental results are also compared with two different shear models namely ACI Code equation and Indian Standards (IS 456:2000).

**Keywords:** Measurements Shear strength, Concrete

## **Proposal for Establishment of DC High Voltage Standard up to 300 kV at NPL**

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### **Abstract**

This paper describes the design and plan of implementation of D C high Voltage measurement laboratory up to 300kV. The Precision high Voltage divider is the Primary standard of the laboratory, it is traceable to the Josephson Voltage Standard through Binary step up method. Two similar dividers of 150 kV each connected in sequence of steps that combine and separate to evaluate voltage coefficient of each divider up to 300kV. The expended uncertainty for the divider up to 300kV is  $35 \times 10^{-6} \mu\text{V/V}$ . To confirm the validity of the method, the ratio at 1 kV is compared with the resistance ratio of the divider is with in  $15 \times 10^{-6}$ .

The space required to establish DC High Voltage Standard of 300 kV are 5 m X 10 m X 6 m, It can be accommodate in existing DC high voltage Laboratory with some change of arrangement like shielding and shifting of fence. The automation of High voltage source through optical fibre provides galvanic isolation, it's protected the computer from high voltage surge, life of user and also improved the uncertainty of measurement. The advance graphical software to analysis the output data of HV divider and role of stability study to determine voltage coefficient is also discuss in this proposal.

**Keywords:** DC High Voltage, Voltage divider, Binary setup method



## Performance Evaluation of Clamp-on Ultrasonic Flow Meter for Non-ideal Conditions

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### Abstract

The accuracy of flow measurement plays a very vital role in industry and is decisive in the quality and quantity of products. Different types of flow meters based on over a hundred different operating principles are available for flow measurement in pipe lines. Proper installation of flow meter is very much essential for achieving better accuracy in flow measurement. Flow meter performances are affected by valves and bends disturbing the flow as well as by electromagnetic noise, acoustic noise and pulsations, and particles, droplets and bubbles. Different meters respond to installation effect in different ways. For accurate measurement of flow in pipes, it is recommended that a straight section of pipe be installed immediately upstream from the flow meter to avoid distorted flow patterns at the metering location. In this paper the performance of ultrasonic flow meters in non-ideal piping scenarios was studied by laboratory experiments. Clamp-on ultrasonic flow meters has become very popular because it is non invasive and can be used in a wide range of pipe sizes. Currently, calibration of clamp-on ultrasonic flow meter is conducted under proper conditions available at the calibration laboratories. In many existing piping scenarios, however, such flow conditions are impossible to achieve. Apart from this the meter is used in pipe line sizes which is different from the pipe size in which the meter was calibrated. The performance of clamp-on flow meter in non-ideal upstream conditions, and also in varying pipeline diameters is studied here. From this study we could establish that pipe line diameter has significant effect on the accuracy of clamp-on ultrasonic flow meter for same velocity range. The effect of up-stream straight length on the meter performance is also evaluated for various up-stream configurations and was able to establish that a straight length of 10 times pipe diameter shall be provided at site for getting an accuracy of  $\pm 1\%$  in flow rate measurement.

**Keywords:** Clamp-on ultrasonic flow meter, non-ideal conditions, straight length

## Establishment of Metrological Traceability of HF Impedance Standards at CSIR-NPL: Present Status

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### Abstract

LF, HF Impedance and DC Standard laboratory of CSIR-NPL is responsible for maintaining national and reference standards of dc voltage, current, resistance and impedance parameters at low and high frequency. During recent years, this laboratory has initiated the work of establishing the metrological traceability of impedance standards at high frequency (HF). This paper provides the present status of the work performed in this direction. The high precision air-dielectric-coaxial-transmission-lines from 3 to 30 cm are at the apex of the traceability chain of impedance standards at HF. The transfer or reference standards of impedance at HF include coaxial impedance standards, coaxial capacitors, three terminals (3T), and four-terminal-pair (4TP) capacitance standards. LCR meters and impedance analyzers are used as working standards of impedance at HF. The coaxial air-lines (Type 900-LZ series) have been characterized in the frequency range of 10 kHz to 250 MHz using transmission line theory. The characterization procedure of air-lines involves the determination of distributed primary impedance parameters using dimensions of air-lines which are traceable to Length and Dimension Standard. The reference capacitance value (1 kHz) of each of these air-lines has also been measured which thereafter extrapolated upto 250 MHz using resonance technique. The resonance frequency of coaxial air-lines is traceable to Time and Frequency Standard through impedance analyzer. Reference capacitance value of air-lines is traceable to cross calculable capacitance standard which is being maintained as the primary standard of capacitance at low frequency at CSIR-NPL. 3T GR1404 type air capacitance standards of nominal values 100 pF and 1000 pF have been evaluated using frequency-dependent-inductance. The evaluation procedure involves the measurement of reference capacitance value and residual capacitive and inductive parameters of each standard. Frequency-dependent-inductance has been thereafter estimated using linear regression from measured residual inductive parameters. Then frequency dependent capacitance value for capacitance standards has been computed upto 1 MHz. 16380A type 4TP air capacitance standards of nominal values 1, 10, 100 and 1000 pF have also been evaluated using electrical equivalent circuit model (EECM). The approach used for the evaluation is based on the determination of capacitive and inductive residual components of EECM. A measurement automation program has been developed in order to control the evaluation procedure. The working standards of impedance have been calibrated using the evaluated reference standards. The work performed will ensure the establishment of apex level calibration services of capacitance standards at high frequency.

**Keywords:** High Frequency, Impedance, Standards, Metrological traceability, Calibration

## **Selection and Calibration of Acoustic Sensors**

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### **Abstract**

The basic elements of a noise measuring system are a microphone, an amplifier, a signal processor and a readout or monitoring unit. The simplest practical realization of such a system is the portable sound level meter. The microphones are the standard acoustical transducer for all sound and noise measurement. Different types of microphones are available; each has its own advantage and disadvantage. This paper attempts to compile the information on different types of microphones available, its characteristics, calibration methods and relevant standards. This paper also discusses the secondary free field calibration procedure as per IEC 61094/8 -2012 and highlight the contribution of various uncertainty factors affecting calibration.

**Keywords:** Acoustic sensor, Calibration method, Free field

## Performance Study of Capacitance Type Probes in Level Measurement

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### Abstract

In petroleum dispensing station, liquids such as petrol, diesel, and other hydrocarbons are stored in tanks of different capacities. The amount of such liquid stored can be found by measuring level of the liquid in the container or tank, which is done by manual dip method in the present scenario. Continuous level sensors measure the level to determine the exact amount of fuel in a continuous manner. In petrol and diesel dispenser outlets, these type of probes are becoming popular for online level monitoring in the storage tanks. Level probe is an ideal solution for the dispensing station in fuel inventory monitoring system. The level probe monitors fuel density and inventory levels in the tanks and provides accurate, reliable information without manually taking tank readings. For the retail outlet automation, additional features of the level probes communicate the status of tank contents, including volume, temperature, mass, water level and continuous tank leak detection. The computer - web interface feature allows authorized users access to tank information remotely from any computer connected to the internet or wide area network, as well as custom alerts which can be sent to email or mobile devices. These type of probes are tested for its accuracy at the FCRI laboratory before installing at site. In this paper we discuss on different types of probes, working principle, testing methods and advantages of the level probes in continuous level measurement.

**Keywords:** Level probe, Dispensing station, Automation, Density.

## Studies on Use of Ferroelectric Relaxor as High Pressure Sensor

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### Abstract

Development of a low cost high pressure sensor with reasonable accuracy is always a challenge for researchers and metrologists. The ferroelectric relaxor exhibits high strain response and high dielectric constant near the transition temperature. During last few decades, these relaxors have extensively been studied and found useful in several applications in capacitors, memories, optical wave guide and detectors etc. The present paper describes an effort made to find new application of ferroelectric material as pressure sensor. The Present study describes the studies carried out on pressure and temperature dependent dielectric properties of (1-x) PbFe<sub>2/3</sub>W<sub>1/3</sub>O<sub>3</sub> - xPbTiO<sub>3</sub> binary relaxor systems with x=0, 0.02, 0.1 and 0.18 in the pressure range. In the present investigation, we have optimized the concentration of lead titanate (PT) in lead iron tungstate-lead titanate (PFW-PT) binary system to obtain high pressure coefficient and low temperature coefficient which is a prime requirement for a binary system to be used as a high pressure sensing element. The sample specimens are prepared by conventional mixed oxide route. The results thus obtained clearly establish the feasibility of use of PFW with 2% PT as pressure sensing element having low temperature and high pressure coefficient in the pressure range 0 to 416 MPa and temperature range 283 to 323K. The results are discussed in details.

**Keywords :** Relaxor; Dielectric; Pressure; Sensor

## **A Knowledge Based Framework for Metrology Based Homologation and Traceability**

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### **Abstract**

In the quest for producing high quality products, manufacturers are becoming more and more aware of taking control over all stages of the entire product lifecycle. An important requirement towards meeting this objective is deploying of systematic methods aimed towards standardization and streamlining of processes. It is also highly desirable that the procedures, heuristics and evaluation criteria outlined in the homologation standards be integrated directly by use of automation into the daily testing or measurement processes, to streamline the process and render it accurate and productive. The field of Knowledge Management effectively addresses all these requirements. This paper elucidates knowledge based techniques deployed for streamlining standard operating procedures in order to ensure conformance of metrological measurement processes as per homologation standards. A case study is presented on application of knowledge management to the metrological process. Also, a knowledge based framework for ease of traceability is outlined. This systematic way of working through knowledge management techniques thus achieves concurrent objectives of continual improvement, integration of homologation knowledge into daily metrological processes, all round efficiency and accuracy, and ease of traceability.

**Keywords:** Knowledge Management, Traceability, Automation, Standardization, Homologation

## **Frugal Techniques for Streamlining Calibration Process of Mechanical Measurements for Automotive Applications**

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### **Abstract**

Measurement process capability of an instrument is a requisite for qualifying the instrument for use in a particular application in the automotive industry. This calls for precise and error-free quantification of uncertainty of calibration of the instrument. This quantification thus needs to meet the second generation measurement process capability criteria, and requires a high level of accuracy. To ensure the fidelity of calibration, the authors hereby elucidate an innovative knowledge based frugal methodology that integrates the entire workflow from calibration data acquisition phase, data management, uncertainty calculations, reporting and application of heuristics per standards. This is achieved by leveraging cost effective virtual platforms and instrument interfaces. This streamlines the calibration and certification procedure for equipment used to measure mechanical quantities such as mass, load, torque, and pressure for automotive R & D testing applications. Deployment of such systematic knowledge based tools streamlines the entire calibration procedure, fosters standardization and ensures fidelity of instrument calibration. Advantages of this are reflected downstream where it lends a robust hand to high quality automotive R & D testing and product development which are crucial to build the best of automotive products.

**Keywords:** Frugal Engineering, Knowledge Management, Uncertainty, Process Capability Index, Automation

## Experimental Investigation on Effect of Orifice Diameter on Discharge Coefficient

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### Abstract

Orifice meters are one of the most commonly used instruments for fluid flow measurement because of its low cost, ruggedness and simplicity in construction. In closed conduits, Coefficient of discharge (Cd) of an orifice plate is used to find the actual flow rate. This is accomplished by measuring differential head across the orifice and calculating the theoretical flow rate and multiplying by Cd. For the last two decades, large number of different type of orifice plate assemblies were calibrated at our institute for various industries. An analysis was done on the calibration data of various orifice plates to study the variation of Cd with respect to beta ratio,  $\beta$  ranging from 0.30 to 0.70. The Cd value was analyzed for different beta ratios with respect to Reynolds number. This paper attempts to correlate Cd, beta ratio and Reynolds number for different flow rates ranging from high, medium to low flow rates and to optimize the beta ratio for efficient pipe flow measurement.

**Keywords:** Coefficient of Discharge, Beta ratio, Head loss.



## **Experimental Investigation of RF Sputtered SiO<sub>2</sub> Thin Films for Evaluation of Uniformity**

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### **Abstract**

SiO<sub>2</sub> layers were deposited on Si substrate in an UHV chamber by magnetron sputtering from a high purity silicon dioxide target with working pressure of 1.9 mTorr. The substrate temperature was held at 300 °C and the films were deposited to a thickness of 300 nm, at a rate of 0.4 Å /sec. Thickness measurement of the deposited SiO<sub>2</sub> thin film was performed by a Profilometer-contact type and Ellipsometry for evaluation of uniformity of films. The results of the measurement proved that for RF sputtered SiO<sub>2</sub> thin films Ellipsometry is the suitable method for evaluation of uniformity as in case of profilometer measurements substrate effects creeps into the measurement accuracy.

**Keywords:** SiO<sub>2</sub>, Thin films, RF sputtering, Ellipsometry

## Variation in Ozone Concentration in Winter Season over Delhi

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### Abstract

In this study, the concentrations and trends of tropospheric ozone over a study site (National Physical Laboratory) in Delhi, India have been quantified by a continuous analysis of the winter season data for the year 2013-14 and 2015-16. Although ozone is a trace gas, it still plays a big role in atmospheric photochemistry and as a strong oxidising agent; it controls the oxidation capacity of the atmospheric cleansing agent, OH radical. Tropospheric ozone concentration depends on the photochemical oxidation of its precursor gases, carbon monoxide (CO), methane (CH<sub>4</sub>) and non-methane hydrocarbon (NMHC), in the presence of nitrogen oxides (NO<sub>x</sub>). Life time of tropospheric ozone is in weeks in free troposphere and as it moves downwind, the concentration increases in the downwind area. Ozone hourly concentration was measured by using Ozone analyser (Horiba APOA-370) which worked on cross flow modulated ultraviolet absorption method and consisted of an internal dry-method sampling device to attain the highest levels of sensitivity and accuracy. The average mixing ratio recorded during winter 2013 and 2015 was 25.20±3.92 ppb and 30.90±4.30 ppb respectively. The maximum and minimum concentration recorded in winter 2013 was 56.9 ppb and 0.1 ppb respectively and 71.5 ppb and 0.1 ppb respectively in 2015.

The averaged diurnal variation show low mixing ratio of ozone in early morning and night hours but it also shows a gradual increase in concentration as the day progressed since the precursor gases break in the presence of sunlight to form tropospheric ozone. The peak value of ozone was observed during 12 pm to 4 pm and after that it started to fall. The wide increase in mixing ratio was observed as 11.76 ppb from 2013-14 to 2015-16 and it might be due to the rise in concentration of precursor gases since vehicular activity in Delhi is elevated (Fig.1). Production of tropospheric ozone was observed low during the winter seasons than the summers of year 2013 and 2015. The more sunlight availability for a longer duration might be the main reason for the high summer ozone production.

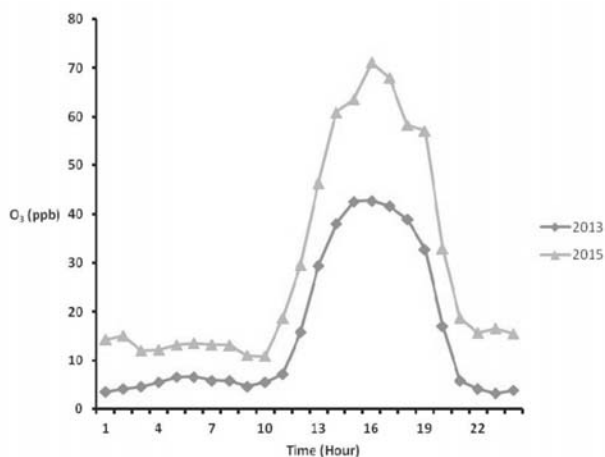


Fig. 1: Variation in ozone concentration during winter 2013 and 2015

**Keywords:** Ozone, Seasonal variation, Intraction of O<sub>3</sub> and precursor.

## To Study the behavior of Capacitance Standards as a function of Frequency, Temperature and Time using Measurement Automation

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### Abstract

LF, HF Impedance and DC Standards laboratory of CSIR-NPL has the responsibility to establish and maintain primary and reference standards of impedance at low and high frequency. It is required to study the stability, temperature and frequency characteristics of impedance standards for the advancement in their measurement techniques. In the reported work, the behavior of air (10, 100 and 1000 pF) and mica type capacitance standards (0.1, 0.01 and 0.001  $\mu$ F) have been studied with respect to frequency, temperature and time using measurement automation program (MAP) developed in LabVIEW programming environment. The ultra-precision capacitance bridge AH2700 and high-precision ( $\pm 0.03$   $^{\circ}$ C) variable temperature air-bath Guildlines 5032 have been automated using SCPI (Standard Commands for Programmable Instruments) commands. To determine the change in effective value of capacitance standard with respect to frequency, the measurements have been carried out using MAP at set of frequencies ranging from 55 Hz to 20 kHz. It has been observed that the value of capacitance standard decreases with the increase in frequency. To determine the temperature coefficient (TC) of the capacitance standards, initially air bath has been set at a temperature of 24  $^{\circ}$ C and thereafter MAP facilitates the user to compute their temperature coefficients using capacitance bridge. Then the temperature of air bath is increased in a step of 1  $^{\circ}$ C from 24  $^{\circ}$ C to 28  $^{\circ}$ C and TC have been computed for each of the capacitance standard at every temperature. The whole process has been repeated by decreasing the temperature of air bath in reverse direction, i.e., from 28  $^{\circ}$ C to 24  $^{\circ}$ C in a step of again 1  $^{\circ}$ C. A small hysteresis effect has been observed in the TC of standards both in forward and reverse direction. The TC of 0.001 and 1  $\mu$ F standards have been found to be 46 and 22 ppm respectively with an uncertainty of  $\pm 0.5\%$  per  $^{\circ}$ C. The stability of each capacitance standard at 1 kHz has also been studied by maintaining the constant temperature of 25  $^{\circ}$ C. The temperature of the air-bath has been monitored regularly using MAP. The standard deviation in the value of 1  $\mu$ F mica capacitance standard has been found to be 4 ppm with its average value = 0.999944  $\mu$ F. This kind of study may be useful in Inter-Comparisons & ILC programs where each parameter related to the standard, contributes significantly to the measurement uncertainty.

**Keywords:** Measurement Automation, Capacitance Standard, Temperature Coefficients, Frequency, Stability

## Measuring Human Intelligence Through Fingerprint Patterns

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### **Abstract**

The word dermatoglyphics comes from two Greek words (derma, skin and glyphe, carve) and refers to the friction ridge formations which appear on the palms of the hands and soles of the feet. Dermatoglyphics is the scientific study of fingerprints. The term was coined by Dr. Harold Cummins, the father of American fingerprint analysis. Personality can be traced early in the mother's womb, and it is reflected in fingerprints (dermatoglyphics). Since each person's fingerprints are unique, we can understand one's innate potential, personality, and preferences by analyzing dermatoglyphics. In simple words, Dermatoglyphics can disclose our inherent qualities and talents. It is analyzed and verified with facts in anthropology, genetics, medicine and statistics. Dermatoglyphics helps to understand your student's natural character traits, Identify best learning style for students, and identify student's innate talents and weaknesses. The fingerprint patterns are mainly classified as loop, arch and whorls. We intend to build an automatic fingerprint classifier that gives the knowledge about an individual by pattern detection and then by the conclusions drawn from the study of dermatoglyphics.

**Keywords:** Human intelligence, Finger print

## Surface Ozone Concentration and its Behavior with Aerosols at an Urban Site of Delhi, India

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### Abstract

The study explores measurements of the concentrations of ozone ( $O_3$ ) alongside particulate matter ( $PM_{2.5}$  and  $PM_{10}$ ) at the CSIR-National Physical Laboratory, Delhi from January 2012 - December 2014.  $O_3$  is a greenhouse gas and a potent oxidant, elevated concentrations of which are known to cause adverse effects. Due to similar bearings on health and air quality, PM is also studied. The temporal progression of both the parameters depicted trends characteristic to an urban polluted area (Fig.1, 2). Mean mixing ratio for  $O_3$  was calculated to be  $29.5 \pm 7.28$  ppb. The concentrations were highest during the summer season. Conversely, PM exhibited highest concentrations during the winter months implying that their

respective high pollution periods are not concurrent on seasonal timescales and on a diurnal scale, they are weakly negatively correlated, since  $O_3$  is expected to sink into aerosol. Monthly average  $PM_{2.5}$  concentrations ranged from  $32 \pm 15.75$  to  $383.82 \pm 116.40 \mu g/m^3$  while for  $PM_{10}$ , it ranged between  $76.67 \pm 27.62 \mu g/m^3$  to  $403.16 \pm 128.92 \mu g/m^3$ . The aerosol particles are known to contain the elemental carbon (EC) core coated by organic material which might reduce  $O_3$  by 5-8 % and so, the EC component of both  $PM_{2.5}$  and  $PM_{10}$  were linearly correlated with  $O_3$  and negative correlations were obtained. Atmospheric  $NO_x$ , a major precursor to formation of  $O_3$  gets oxidized to  $HNO_3$  which is partly taken up by the aerosols and then presents itself as nitrate ( $NO_3^-$ ) and the trends of these species are expected to reflect  $NO_x$  concentrations.

Keywords: Ozone,  $PM_{2.5}$ ,  $PM_{10}$ , Elemental carbon,  $NO_3^-$

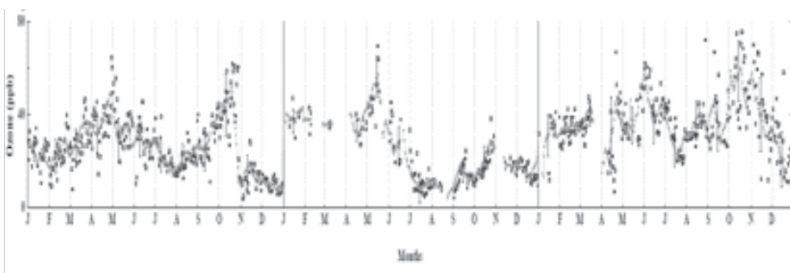


Fig. 1: The time series of the temporal evolution of daily mean online measurements of  $O_3$ .

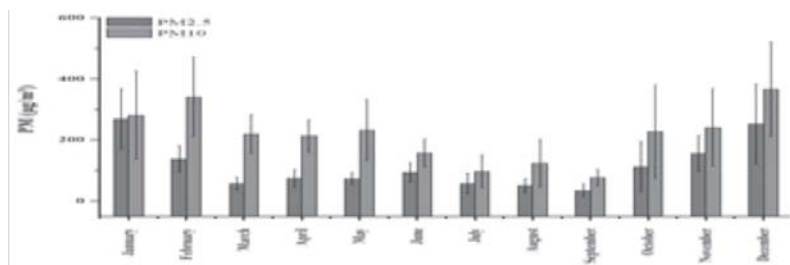


Fig. 2: Monthly variation of aerosol mass loading

## Traceability of Reflection Coefficient Measurements upto 2 GHz at NPLI

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### Abstract

National Physical Laboratory India (NPLI) is the premier research and development center and the National Metrology Institute, which provides traceability in measurements by calibration throughout the country. RF Impedance is an important quantity in Electrical Metrology. This paper presents the measurement technique to provide traceability for reflection coefficient from 1 MHz to 2 GHz at NPLI. A vector network analyzer (VNA) has been used for measurements. Thus traceability of measurements uncertainties and the vector error correction are of great importance. It is achieved through coaxial airline and standard load from dimensional metrology and DC Resistance standard. This paper shows calibration results of reflection coefficient measurements using SOLT technique applied to VNA. The expanded uncertainty of 0.0019 (k=1) has been achieved at 1 MHz for reflection coefficient measurement of the DUC (device under calibration).

**Keywords:** Reflection coefficient, vector network analyzer, measurement, calibration, measurement uncertainty, traceability

## LabVIEW based Automation and Measurement System for Picoampere Current Source using the Capacitance Charging Method

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### Abstract

A picoampere current generator using capacitance charging by a linear ramp voltage is developed. The ramp parameters, viz., its slope and slope polarity, amplitude and duration are factors that decide the magnitude and polarity of the current generated, measuring time and the amount of data that will be acquired. The ability to generate currents over a wide range of values using a single setup depends on the ability to reconfigure the ramp parameters to the required values as needed. It is difficult to realize the desired flexibilities in a purely hardware oriented design. We have used automation to eliminate the hardware constraints while optimizing its capabilities. In this paper implementation of computer automation in the various aspects of the current generator's design, operation and measurement is presented. With computer control, the ramp slope and its polarity, ramp duration and amplitude are made software configurable which allow generation of currents of both polarities over a range of values and different measuring modes with provision for repeating a measurement as many times as needed without any hardware modifications. The system can be configured for generation of highly linear ramps of any value between  $100\text{mVs}^{-1}$  and  $1\text{mVs}^{-1}$  and amplitudes of any value up to  $10\text{V}$  by software inputs. The automation software is developed in LabVIEW and its details are also presented. The software is designed to communicate between PC and the instruments, monitor experimental parameters, acquire and store the measurement data. Program variables are input through the interactive front panel. LabVIEW with its extensive array of built-in functions for communication between the instruments and the computer, data acquisition, data analysis and data visualization made the programming task fast and easy. The current generator design is tested and validated for current generation in the range of  $100\text{pA}$  to  $1\text{pA}$  using a  $1\text{nF}$  air capacitor.

**Keywords:** Capacitance Charging, Linear Ramp, Constant Current Source, Data Acquisition

## **Traceability for DC charge measurements at CSIR-NPL: Present Status**

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### **Abstract**

A calibration system for electric charges in the range of  $2\mu\text{C}$  to  $10\text{pC}$  is established. Initial work carried out under the project "Generic Development of Nanometrology at NPLI" achieved measurements in the range of  $2\mu\text{C}$  to  $200\text{pC}$ . The system has subsequently been modified and improved which resulted in extending the lowest measurement range down to  $10\text{pC}$  at present. Depending on the charge level, two methods have been used for standard charge generation, viz., the current-time method ( $Q = I t$ ) for charges in the micro-coulomb range and the capacitance charging method ( $Q = C V$ ) for charges of lower values. Measurement uncertainties realized are in the range of  $0.01\%$  at  $2\mu\text{C}$  and  $1\%$  at  $10\text{pC}$ . In this paper we will present the details of the calibration setup and the measurement results, particularly for charges of nanocoulomb and lower.

**Keywords:** Calibration, Electric Charge, Uncertainty.



## Precise and Accurate Determination of Isotopic Abundance Ratio of $^{107}\text{Ag}/^{109}\text{Ag}$ in Silver Granules by Sector Field Inductively Coupled Plasma Mass Spectrometry

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### Abstract

Isotopic fractionation of elements in the natural environment occurs due to the atmospheric, geologic, biologic etc. process, which varies from place to place through transport mechanism. The isotopic ratio of stable isotopes helps as an isotopic signature in natural system to identify the source. High resolution (sector field) inductively coupled plasma mass spectrometry is a very good tool for the measurement of stable isotopic ratio analysis on the basis of mass-to-charge ratio of isotopes of a particular element. In order to attain reliable and precise measurement of the isotopic ratios of the element of a material, the use of matrix based isotopic reference materials are necessary. The isotopic reference materials provide either 'δ' measurement or absolute isotopic ratio to compare the isotopic ratio result of the desired element in the compound. In the present study, an effort has been taken to develop a precise and reliable measurement method to determine the  $^{107}\text{Ag}/^{109}\text{Ag}$  ratio for an absolute isotopic reference material of silver granules. Initially, the silver granules were cleaned properly. Five replicates of known quantity were dissolved in high purity  $\text{HNO}_3$  and made to appropriate dilution by mass. The isotopic ratio analysis of  $^{107}\text{Ag}/^{109}\text{Ag}$  was carried out by a high resolution inductively coupled plasma mass spectrometry (HR-ICPMS, AttoM, Nu Instrument, U.K.). Single point calibration method was opted for the calibration of HR-ICPMS using NBS USA make Standard Reference Material 978a, which certified for absolute isotopic abundance ratio of  $^{107}\text{Ag}/^{109}\text{Ag}$  is  $1.07638 \pm 0.00022$ . The 'δ' measurement value of absolute isotopic abundance ratio of  $^{107}\text{Ag}/^{109}\text{Ag}$  in silver granules was also calculated with the deviation from the certified value of NBS, SRM 978a. The evaluation of expanded uncertainty in measurement of  $^{107}\text{Ag}/^{109}\text{Ag}$  was done at 95% confidence level ( $k=2$ ) according to EURACHEM GUM GUIDE. The absolute isotopic abundance ratio of  $^{107}\text{Ag}/^{109}\text{Ag}$  in silver granules is found to be 1.06923 which is very close to the certified value of the standard. The associated measurement uncertainty is found to be less than 0.05 %.

**Keywords:** Isotopic ratio, silver granules, sector field, mass spectrometry

## Measurements of Surface Ozone and its Precursors in Delhi, India

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### Abstract

Continuous measurements of the surface ozone ( $O_3$ ), oxides of nitrogen ( $NO_x$ ), carbon monoxide (CO), methane ( $CH_4$ ) and non-methane hydrocarbons (NMHCs) have been carried out at an urban site of Delhi, India during 1-31, May 2014 to estimate the ozone production efficiency (OPE).  $PM_{2.5}$  and  $PM_{10}$  samples were also collected periodically alongwith meteorological parameters (temperature, relative humidity, wind speed and wind direction etc.,) to correlate with surface  $O_3$ . In the present study, the average mixing ratios of surface  $O_3$ ,  $NO_x$ , CO,  $CH_4$  and NMHCs were recorded as  $38.7 \pm 6.9$  ppb,  $32.6 \pm 5.8$  ppb,  $1.3 \pm 0.4$  ppm,  $2.6 \pm 0.2$  ppm and  $131.2 \pm 20.1$  ppb, respectively. The surface  $O_3$ ,  $NO_x$ , CO,  $CH_4$  and NMHCs have shown the prominent diurnal variations during study. Fig. 1 shows the comparison between diurnal variation of observed and estimated (using precursors gases as inputs to the photo chemical model) surface  $O_3$ . The result reveals that the surface  $O_3$  was negatively correlated with  $NO_x$ , CO,  $CH_4$  and NMHCs. In the present case, the linear scatter plot analysis shows that the  $PM_{2.5}$  and  $PM_{10}$  present in the ambient air of Delhi influence the production of surface  $O_3$  alongwith precursors at observational site of Delhi.

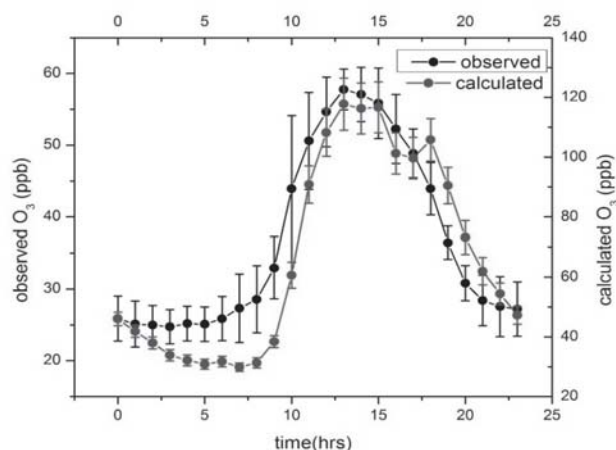


Fig. 1: Diurnal variation of observed and calculated  $O_3$  during summer 2014.

**Keywords:** Surface  $O_3$ , Precursors gases, Particulate matter, OPE.

## Design and Development of Humidity and Temperature Data Logger for Ambient Condition Monitoring of Calibration Laboratories

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### Abstract

Monitoring of environmental condition in calibration laboratories is an essential requirement to achieve ultimate measurement uncertainty and repeatable results. Generally, periodic temperature and humidity data is manually recorded from a calibrated temperature and humidity indicating device. Reading the data on time in a periodic manner performed by a technician of the laboratory is a tedious and cumbersome task. With the advent of computer controlled and automated systems various cumbersome tasks have been simplified. In this article a fully automated low cost system for recording temperature and humidity data is discussed. The device is indigenously developed and interfaced to computer for data transfer at regular interval specified by the user. The RH and temperature sensor used is DHT22 which provides serial digital data for RH and temperature with an uncertainty of  $\pm 2\%$  and  $\pm 0.5^\circ\text{C}$  respectively. The resolution in humidity and temperature are 0.1% and  $0.1^\circ\text{C}$  respectively. ATmega 8535 microcontroller is used as the main processor and performing functions such as receiving serial data from sensor, decoding it and converting it into readable form, display on LCD screen and also, if required; sending data to computer. LabVIEW program has also been developed to receive periodic data from the device. Parameters such as Serial communication port, data recording interval are specified through the developed graphical user interface (GUI). The minimum data recording interval can be 5 second. The GUI developed displays the humidity and temperature variations graphically.

**Keywords:** Humidity and temperature; DHT 22 sensor; Microcontroller; Serial communication; LabVIEW program.

## Fog Forecasting and Variability with Physico-Chemical Parameters in Winter Season By Using Time Series Modelling

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### Abstract

Short-term forecasting of fog is a difficult subject which can have a large societal impact. Fog appears in the surface boundary layer and is driven by the interactions between land surface and the lower layers of the atmosphere. Air-traffic security and operational efficiency depend heavily upon accurate and timely forecasts of fog. Poor visibility conditions can strongly decrease the efficiency of area traffic flow. The goal of the proposed methodology is to improve the local prediction of poor visibility and fog at Delhi. The historical data of atmospheric boundary layer (ABL) along with meteorological parameter measured during foggy days in winter season (December-January) at New Delhi are used for fog forecasting. Artificial neural network (ANN) and Adaptive Neuro-Fuzzy Inference System (ANFIS) have an wide range of applications in air quality management. Wavelet transformation as a preprocessing approach can improve the ability of a forecasting model by capturing useful information on different resolution levels. The objective of this study is to compare several data-driven models for fog forecasting. In this research, a number of model structures for Artificial Neural Network (ANN), Adaptive Neuro-Fuzzy Inference System (ANFIS), Wavelet-ANN and Wavelet-ANFIS models have been compared to estimate their performances to forecast fog.

**Keywords :** Fog, Forecasting, Mixing Height, Artificial Neural Network (ANN), Adaptive Neuro-Fuzzy Inference System (ANFIS)

## Development of Mixing Height based Fog Predication Models using Artificial Neural Network and Fuzzy Logic

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### Abstract

Fog prediction is extremely important since it not only causes low visibility but also is considered as a hazard as it disrupts the normal life and traffic. The main objective of the present study is to utilize feed forward back propagation type of artificial neural network (ANN) and fuzzy logic to find the combined effect of mixing height, temperature and humidity on the foggy days. For developing the models, six days comprising hourly average temperature, humidity and mixing height have been used. To ensure the effectiveness of Artificial neural network and Fuzzy logic techniques, different models employing a different training and test data set have been tested. The criteria of performance evaluation are calculated for estimating and comparing the performances of Artificial neural network and Fuzzy logic models. Finally, the models have been tested and the results confirm that the proposed models are competent to predict the fog using mixing height, temperature, humidity. The performance comparisons of Artificial neural network and Fuzzy logic models due to MAE (Moving Average Error), RMSE- R2 (Root-Mean-Square error) criteria, show that Fuzzy logic models yields better results.

**Keywords:** Mixing Height, Fog, Artificial neural network, Fuzzy logic

## Spatio-temporal Chemical Characteristics and Source Apportionment of PM<sub>10</sub> over Indo Gangetic Plain of India

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### Abstract

The paper presents the spatio-temporal variation of chemical compositions (organic carbon (OC), elemental carbon (EC), water soluble inorganic ionic components (WSIC), total carbon (TC), total nitrogen (TN) and isotopic ratios of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  along with  $\delta^{13}\text{OC}$ ) of PM<sub>10</sub> over three locations (Delhi, Varanasi and Kolkata) of Indo Gangetic plain (IGP) of India for the year 2011. Average mass concentration of PM<sub>10</sub> was observed in the middle IGP (Varanasi:  $206.2 \pm 77.4 \mu\text{g m}^{-3}$ ) as compared to upper IGP (Delhi:  $202.3 \pm 74.3 \mu\text{g m}^{-3}$ ) and lower IGP (Kolkata:  $171.5 \pm 38.5 \mu\text{g m}^{-3}$ ). Large variation in OC values from  $23.57 \mu\text{g m}^{-3}$  (Delhi) to  $12.74 \mu\text{g m}^{-3}$  (Kolkata) indicating role of formation of secondary aerosols, whereas, EC have not shown much variation with maximum concentration over Delhi ( $10.07 \mu\text{g m}^{-3}$ ) and minimum over Varanasi ( $7.72 \mu\text{g m}^{-3}$ ). For Delhi, the average concentrations of TC and TN of PM<sub>10</sub> were  $53.0 \pm 33.6 \mu\text{g m}^{-3}$  and  $14.9 \pm 10.8 \mu\text{g m}^{-3}$ , whereas  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  of PM<sub>10</sub> were  $-25.5 \pm 0.5\text{‰}$  and  $9.6 \pm 2.8\text{‰}$ , respectively. For Varanasi, the average values of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  of PM<sub>10</sub> were  $-25.4 \pm 0.8\text{‰}$  and  $6.8 \pm 2.4\text{‰}$ , respectively. The average concentrations of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  were  $-26.0 \pm 0.4\text{‰}$  and  $7.4 \pm 2.7\text{‰}$ , respectively over Kolkata. Principal Component Analysis (PCA) identifies the contribution of secondary aerosol, biomass burning, fossil fuel combustion, vehicular emission and sea salt to PM<sub>10</sub> mass concentration at the observational sites of IGP, India. The isotopic analysis revealed that biomass burning, vehicular emission and secondary inorganic aerosols were likely sources of PM<sub>10</sub> mass over IGP, India. Backward trajectory analysis indicated the influence of continental type aerosols being transported from the Bay of Bengal, Pakistan, Afghanistan, Rajasthan, Gujarat and surrounding areas to IGP region.

**Keywords:** PM<sub>10</sub>, Chemical characteristics, Source apportionment, Carbon and nitrogen isotopes.

## High Precision Measurements of a Piston Diameter of a Primary Pressure Standard

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### Abstract

The traceability of pressure balance type primary pressure standards is realized through high precision dimensional measurements. In order to achieve utmost measurement uncertainty associated with pressure measurements using pressure balanced based primary pressure standards, it is essentially required to measure the form geometry of piston cylinder assemblies with utmost precision. Among the form geometrical parameters of the piston cylinder assembly, accurate and precise measurement of piston diameter is of foremost important. Therefore, the associated pressure measurement uncertainty is always limiting to the uncertainty achieved in measurement of piston diameter. In the present paper, efforts have been made to measure the piston diameter (nominal diameter, 2.5 mm) of a controlled clearance piston gauge (CCPG) primary hydraulic pressure standard (CCPG1000 / NPL-H1), recently established at NPL for hydrostatic pressure measurements up to 1.0 GPa, using a high precision Form Tester, make-Mitotoyo, model RA-2200CNC within the resolution 0.001  $\mu\text{m}$ . During the measurements, the centring / tilting values have been controlled well within 0.012  $\mu\text{m}$ . Before performing measurements, the high precision Form Tester was calibrated using a hemisphere roundness reference standard, well calibrated by METAS within the uncertainty of  $\pm 0.01\mu\text{m}$ . The linear measurement of diameter of piston were performed using contact probe method utilizing high sensitive probe having resolution of 0.001  $\mu\text{m}$  and the rotary indexing table of the Form Tester is having provision of 3 mounting Jaw Chuck for holding the piston. The measurements of diameter were performed at 19 measurement positions along the piston engagement length (50 mm), starting at 5.52 mm from bottom to 41.51 mm at top in a space of 2 mm each. After the adjustment of first piston position, the rotary table is rotated for continuously recoding the deviations of diameter from starting at 00 to 3600. The value of diameter at this z-position is determined as the average from the maximum and minimum diameter values at their corresponding angles. The measurements were repeated in a similar way for the 19 z-positions. The average diameter is found to be 2.521498 mm within the expanded measurement uncertainty of +0.018  $\mu\text{m}$ , determined from the measurements performed at all z-positions. The improved dimensional measurements thus performed have helped us to improve the relative measurement uncertainty in zero pressure effective area ( $A_0$ ) of CCPG100 from  $24 \times 10^{-6}$ , estimated earlier to less than  $10 \times 10^{-6}$ .

**Keywords:** Piston diameter, pressure standard

## **Compensation of Error due to Change in Buoyancy of an Absorbing Target at High Ultrasonic Power Measurement**

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### **Abstract**

Radiation force balance (RFB) is well known, universally accepted primary approach for measurement of total ultrasonic power. At low power (typically few mW) measurement type A uncertainty is highly affected due to the inherent resolution of the microbalance in use. At higher power level (typically few watts) error contribution due thermal heating of the absorbing target becomes dominant. Manual recording of microbalance output does not detect such error and result in over estimation of the ultrasonic power output. In this article method of continuous recording of balance output to estimate the contribution of error due to thermal expansion of target is described. The approach can be used to detect error contribution in the ultrasonic power measurement due to thermal heating of the absorber and can be eliminated using a suitable mechanism.

**Keywords:** Total ultrasonic power; Radiation force balance; Thermal heating



## A Comparative Study of Time Domain Features for SEMG Signal for Hand Movement Classification

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### Abstract

Surface Electromyography (SEMG) is widely used to investigate the muscular activities. It is important to know the features that can be extracted from SEMG signal. For efficient classification and recognition of the SEMG signals, three main cascaded modules have been considered that consist of data pre-processing, feature extraction and classification modules. In the present research work fifteen features have been investigated such as Integrated EMG, Mean Absolute Value 1 (MAV1), Mean Absolute Value 2 (MAV2), Waveform Length (WL), Variance (VAR) etc. Most of them are defined in time domain. SEMG signal from the extensor superficial muscles for channel 1 (i.e. the back of the forearm) of five subjects and the flexor digitorum superficial muscles for channel 2 (i.e. front mid of the forearm) were acquired at sampling frequency 5000 Hz to classify two hand movements i.e. hand open and hand close. In the spectrum of SEMG signals, most of the information is contained in frequencies up to 300 HZ. A fourth order Butterworth band pass filter with cut off frequencies 20 Hz and 300 Hz has been used to filter surface EMG signals. For classification, Support Vector Machine (SVM) classifier has been used as its well proved.

The result shown in figure indicates the classification accuracy of hand open and hand close movement with respect to different features for channel 1 and channel 2. For channel 1, maximum classification accuracy is for TM3 feature and minimum is for ZERO crossing features. So, for channel 1, TM3 feature should be selected for open and close movement. For channel 2, maximum classification accuracy is for WL, AAC and DASDB features and minimum is for TM4 feature, so for channel 2 signal any feature among WL, AAC and DASDB can be used for open close movement. Mean accuracy of open close movement classification for channel 1 was (57.62%) and for channel 2 it was (75.93%), which suggest that signal from channel 2 is better for controlling open close movement. But feature selection will play an important role because the standard deviation for channel 2 (14.67) is higher than the channel 1 (2.60) i.e. the features taken in consideration will not affect the classification accuracy for channel 1 whereas for channel 2 it is other way round. This piece of research work will be very useful for muscle (flexor digitorum superficial muscles) and efficient feature selection of SEMG signal to operate exoskeleton hand movements.

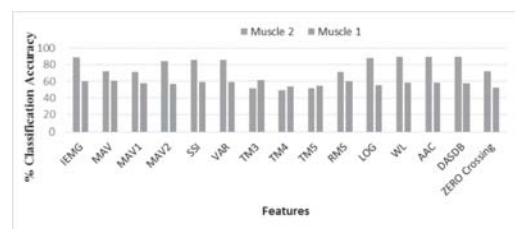


Fig : % Classification accuracy with features

**Keywords:** SEMG signal, exoskeleton, hand movement, Support Vector Machine

## Piezoresistive Based Wrist Pulse Acquisition System

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### Abstract

Ayurveda tells the root cause of the disease through three doshas i.e. vata, pitta and kapha. These doshas are the primary disease causing agents in the human body. These doshas are biological energies originate throughout the human body and mind. The doshas derive from the Five Elements and their related properties. Vata is composed of Space and Air, Pitta of Fire and Water, and Kapha of Earth and Water. The health status of person is examined by ayurvedic physician by feeling palpation from three fingers (index, middle and ring) placed on the radial artery for vat, pit and kaph respectively. Examination of pulse (NadiParikshan) requires a lot of experience as well as a high level of skill in pulse reading. It depends upon perception of the practitioner, hence there is a need to develop pulse diagnosis system to obtain accuracy in diagnosis of disease. Present work focuses on design and development of pulse diagnosis system, in which one sensor was utilized. MPXM2053D sensor from FREESCALE was used to acquire the pulse signals. Thereafter, signal conditioning circuit was designed using instrumentation amplifier and amplified signal was displayed and analyzed on Tektronix MSO 2014 mixed signal oscilloscope 16 CH MSO, Fig.1. Data obtained from MSO was saved in excel spread sheets which was basically amplified signal obtained using instrumentation amplifier. Pulse signal contains the information of the pulse in the form of amplitude and frequency. The excel sheets were imported to LabView software of National Instruments. Further filtering of pulse signal was performed and waveforms obtained were displayed. Single channel wrist pulse signal acquired was compared with available literature waveform, Fig.1 for proof of verification.

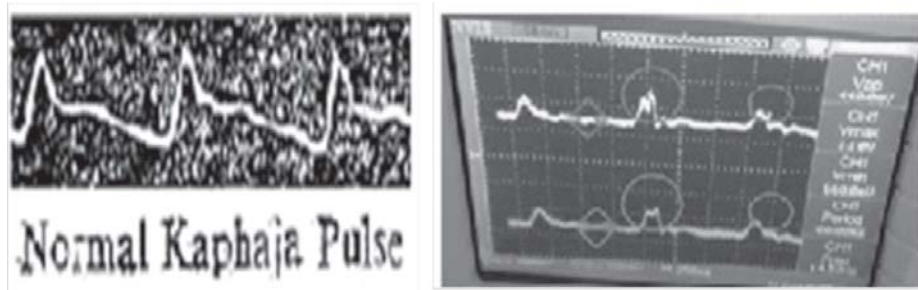


Fig. 1 : Literature waveform and obtained waveform

**Keywords:** Ayurveda, Pulse signals, Signal conditioning circuit, LabView, Instrumentation amplifier.

## Investigation and Development of Cognitive Abilities in Basketball Sportspersons

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### Abstract

Augmenting the mental abilities is as necessary for a sportsperson as training the physical abilities, to achieve the top positions in the sports competitions. The present work focuses on refining the cognitive skills such as selective attention and working memory in the basketball sportspersons. Ten sportspersons took part in the study, out of them, five athletes are exposed to the training techniques (test group), while the remaining five athletes are not exposed to any training techniques (control group). Computer-based games are used as training technique for the selective attention and working memory cognitive abilities. The physiological assessment of these athletes included acquiring their electroencephalogram (EEG) data. Two sets of pre and post-training physiological data have been acquired over the duration of the study. The theta/beta band power ratio is used to assess the selective attention ability in the sportspersons. Furthermore, the theta band power (power per radians per sample) is used to measure the working memory ability in the sportspersons. In the first set of physiological data, the results demonstrate that the selective attention skill assessed over the AF3 and AF4 channels of the data acquisition system [Emotiv EPOC headset, Emotiv, Inc., California, USA], is improved on an average by 50% in the test group athletes in comparison to an improvement of 10%, on an average, in the control group athletes. Similarly, the working memory skill assessed over the F3 and F4 channels, is improved on an average by 80% in the test group athletes in comparison to an average increase of 40% in the control group athletes. In the second set of data, the results exhibit an average increase of 60% in the selective attention skill, measured over the AF3 and AF4 channels, in the test group sportspersons in comparison to an average increase of 10% in the control group sportspersons. In the same way, the results show an average increase of 80% in the working memory skill, measured over the F3 and F4 channels of the data acquisition system, in the test group athletes as compared to an average increase of 40% in the control group athletes. The correlation values have been calculated for the physiological testing through Pearson correlation coefficient. A low correlation, in the range of + (0.1 - 0.4), between the pre and post-training physiological data for the selective attention skill has been observed. Additionally, there is a low correlation, in the range of 0 to 0.2, between the pre and post-training physiological data for the working memory skill in the first set of data and medium correlation, in the range of + (0.3 - 0.51), in the second set of data. The physiological and statistical results demonstrate the effectiveness of the training methodology used, for improving the mental abilities of the basketball players.

**Keywords:** Basketball, Cognitive, EEG, Physiological, Selective Attention.

## Vibration Analysis and Identification of Optimal Vibration Frequency on Tree Trunks

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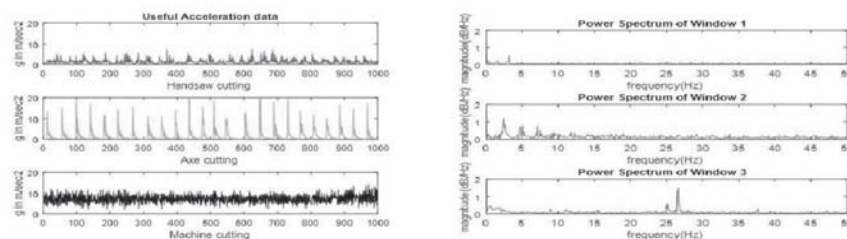
### Abstract

Unauthorized logging of trees is a prevailing socio-economic problem in the nation. In the past few years, number of cases of illegally felled trees has been reported. Exploitation and illegal smuggling has resulted in severe downfall of Indian economy. It is necessary to curb illegal exploitation of precious plantations in the Indian forests and remote locations of the country and an objective oriented research can provide a robust and effective solution. Current research work is a new initiative for developing an effective and robust approach to detect and classify malicious logging activity by exploring vast application of accelerometer sensors. Vibration frequency is considered as the primary parameter to identify the threat scenario since forced vibrations are imparted on the tree trunk by the cutting device, during the time of woodcutting. The factors affecting vibrations generated in the trees are trunk thickness (girth), distance from point of impact and type of cutting device used. In the first phase, research was conducted to identify the range of vibration frequencies generated on the tree trunks during various traditional logging practices that are being followed in the country, e.g. axe cutting, hand-saw cutting and machine-saw cutting of wood. The acceleration

data is acquired from a tree trunk of 0.75 meter thickness [Fig.1 (a)] by positioning the sensor node at 1 meter distance from the point of impact. It is observed that the vibration frequency ranges from 0 - 5 Hz, 0 - 10 Hz and 25 - 30 Hz [Fig.1 (b)] for the axe cutting, hand-saw cutting and electric machine cutting respectively.

An effective framework is developed to analyze and classify the threat scenario and distinguish between normal and threat situations. An "Electronic Surveillance and Threat Detection System (ES-TDS)" is proposed for fast detection of threat scenario and threat type, so that the approximate time to take counter action by the authorized personnel can be decided effectively. This study can be extended by varying the type of woodcutting techniques and type of trees. This research has a huge social and economical impact and will provide the roadmap for further research work.

**Keywords:** Accelerometer, tree vibration analysis, tree vibration frequency range, threat classification, fast threat detection, electronic surveillance of trees, tree monitoring.



**Fig. 1:** (a) Time domain acceleration for different woodcutting methods, (b) power spectrum analysis of acquired acceleration data

## Feature Reduction and Selection of SEMG Signal for Locomotion Identification

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### Abstract

Surface Electromyography (SEMG) signal is the electrical manifestation of the neuromuscular activation associated with a muscle. It contains useful information which can be used to enhance the man machine interface, particularly for lower limb (ankle-foot) prosthetic. Identification of locomotion and anticipation of amputee intention is very crucial for delay free operation of prosthesis. In the present research work, SEMG data of Fibularis longus (below knee) and Biceps Femoris (above knee) muscle of each subject were taken by using wireless SEMG acquisition unit (NeXus-10, TMSi). Five healthy subjects having normal gait walk were selected. Three locomotions were considered i.e. plane walking (L1), stair ascending (L2) and stair descending (L3). The acquired SEMG signal was filtered and segmented using overlapped windowing method with length of 256 ms and window shift of 32 ms. Sixteen time domain features like integrated EMG, variance, slope sign change, auto-regressive coefficients *etc.* and seven frequency domain features like mean frequency, median frequency, peak frequency, power spectrum ratio *etc.* were extracted. Two cases of locomotion identification were considered, in first case SEMG data is divided in two parts with respect to phase of gait walk *i.e.* stance phase (P1) and swing phase (P2), and in second case no division of data was done. Identical methodology was applied for phase dependent and phase independent locomotion identification mode. Support Vector Machine (SVM) classifier is applied over the calculated feature vector for locomotion identification. The calculated features were normalized using min-max normalization method and randomly selected 80% data was used for training and 20% for testing. Locomotion classification accuracy for phase independent classifier is 30.21%-52.56% for M1 and 29.45%-54.36% for M2 for individual feature, similarly for phase dependent classifier it is 18.54%-69.35% for muscle one stance phase (P1M1), 30.76%-51.50% for muscle two stance phase (P1M2), 24.17%-55.92% for muscle one swing phase and 26.65%-57.82% for muscle two swing phase. Further the feature vectors are formed on basis of characteristics of features named as group 1(G1), group 2(G2), group3 (G3) and group 4 (G4). Locomotion classification accuracy for phase independent classifier and phase dependent classifier. Group 1 feature vector shows better identification accuracy for muscle one SEMG signal with phase independent classifier and also for phase dependent classifier for locomotion identification.

**Keywords :** Feature vector, Locomotion identification, SVM, SEMG

## **Future Trend in Conformity Assessment- Influence of Error and Measurement Uncertainty**

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### **Abstract**

Conformity assessment is the demonstration that specified requirements relating to a product, process, system, person or body are fulfilled. Conformity assessment activities may include Testing, Surveillance, Inspection, Auditing, Certification, Registration and Accreditation. In all type of conformity assessment, a measurement result is used to decide if an item of interest conforms to a specified requirement. The decision on complinace of a product to the specification lies on a combination of both error & uncertainty. The paper is about to take decisions on compliance with regulatory or manufacturing limits considering the measurement result accompanied by information on the uncertainty associated with the result. Broadly the area covers are related to (1) safety and health aspects (2) legal metrology (3) Design & manufacturing of products.

**Keywords:** Conformity Assessment, Error in Measurement, Uncertainty in Measurement

## **Automated Primary Ultrasonic Power Measurement Setup for Calibration at mW Region with Reduced Uncertainty**

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### **Abstract**

IEC61161 recommends Radiation Force Balance (RFB) as a primary approach for measurement of total ultrasonic power generated by an ultrasonic transducer. In RFB method ultrasonic output generated from the transducer exerts force on the target attached to a highly sensitive balance. The change in the balance output is directly proportional to the total ultrasonic power radiated by the transducer. Manual observing the output of microbalance for change in effective mass becomes difficult at low power (few mW) level as the change is of the order of few  $\mu\text{g}$  and leads to increased error. Further, the error contribution also depends on the alertness of the system operator. In the view of drawbacks associated with above manual approach of recording balance output it has been decided to interface the balance to personal computer for continuous recording of output data. The continuous recording of balance output (10 readings/sec) during transducer off and on provides useful information about effective change in mass as well as external disturbances. This method is adopted to reduce the external noise and disturbances which are prominent at low power measurement. The improved functionality of this approach particularly below 100 mW over the conventional manual method is described in this paper.

**Keywords:** Low ultrasonic power; Radiation force balance; LabVIEW, Automation

## Expression of CMC using Conservative Regression Equation

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### Abstract

According to ILAC as well as NABL recommendation, when the CMC is expressed in form of a range, calibration laboratory should have proper assumption for the interpolation to find the uncertainty at Intermediate values. Apart from this NABL also recommends that in all the cases, a more conservative fit should be applied by correcting the best fit equation. This paper describes how to derive the best fit equation with lowest uncertainty due to interpolation and a correction factor to be introduced to obtain a conservative fit, by using Microsoft excel platform. The AB (NABL) gives several opportunities of expressing the uncertainty for CMC i.e. a) single value, b) range, c) an explicit function, d) matrix or d) a graphical form. Generally. When expressed in a single value- the absolute or relative terms, the largest value is taken as CMC during accreditation assessment process. This can be done when the MU values at each points do not vary much within the range. However in many cases of calibration, it is observed that 1) Values of MU is widely varying at different point of calibration within a range, 2) a pattern ( either increasing or decreasing) is observed over the range. Such be the case, the CMC can be preferably be described in for of a range, giving the lowest and highest value or vice versa at lowest and highest points of calibration. In such situation, it is imperative to give an suitable interpolation equation in order to obtain the CMC value which a calibration laboratory can give at any intermediate points. This requirement comes from the testing lab, who wants to decide the particular calibration of laboratory equipments for their requirements. Hence, it becomes commercially important for a calibration laboratory to provide the interpolation equation to their prospective customer. Since one may find the interpolation line/curve go the MU points, it becomes necessary to give a correction factor for the reason that the calculated value of uncertainty by interpolation cannot be less than MU value at any point of calibration. The absolute value (without considering the sign) obtained from max negative value in deviation is considered to be the correction factor. This value is added to the best regression equation, previously obtained.

When the so called corrected best regression equation is obtained, it is also called a conservative fit. In such a situation the calculated uncertainty values for calibration points will find above all MU values, excepting where max negative value of deviation was found. In this point the line will pass through that point.

**Keywords:** CMC, Regression analysis, Calibration



## A Novel Approach for Reducing Measurement Uncertainty in Airborne Sound Insulation and Single-number Quantities

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### Abstract

The paper presents an analytical approach in calculating the measurement uncertainty in airborne sound insulation single-number quantity (SNQ). The study ascertains the magnitude of uncertainty difference for single-number quantities considering the sound pressure approach; sound intensity approach and a combined approach utilizing sound intensity method for low frequency measurements (50 Hz to 160 Hz) and sound pressure for the frequency range (200 Hz to 5 kHz). The work presents two case studies: one utilizing the standard deviation of reproducibility recommended in ISO 12999-1:2014, ISO 15186-1:2000 and ISO 15186-3:2002 approach and other utilizing the standard deviation of reproducibility reported by Dijkmans et al. 2013. The analytical results are consistent with Hongisto et al. 2012 recommendations for using a combined approach i.e. sound intensity in range 50 Hz to 160 Hz as per ISO 15186-3 and sound pressure in range 200 Hz to 5 kHz for reducing the measurement uncertainty in sound reduction index and single number quantities in frequency range 50 Hz to 5 kHz. Thus, it is recommended to use ISO 15186-3 for low frequency measurements (50 to 160 Hz) and sound pressure approach (200 Hz to 5 kHz) for reducing the measurement uncertainty in airborne sound insulation in extended frequency range and Single-number Quantities (SNQs).

**Keywords:** Spectrum adaptation terms ( $C$ ,  $C_{tr}$ ), Sound pressure, Sound intensity, Measurement Uncertainty, Single-number quantity (SNQ).

## Determination of Inductive and Capacitive Components of Electrical Equivalent Circuit of Four-Terminal-Pair Capacitance Standards

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### Abstract

LF, HF Impedance and DC Standards laboratory of CSIR-National Physical Laboratory has the responsibility to establish and maintain primary and reference standards of impedance at low and high frequency. Four-Terminal-Pair (4TP) capacitance standards are used upto 30 MHz as reference standards of impedance at CSIR-NPL and other National Metrology Institutes worldwide. In recent years, the work for the establishment of metrological traceability of impedance at high frequency has been initiated at CSIR-NPL. The reported work has been performed in this direction. The 4TP capacitance standards used in the present work are Agilent 16380A type of nominal values 100 and 1000 pF. These standards can be represented by electrical equivalent circuit model (EECM) as described by Suzuki. The admittance of the 4TP capacitance standards has been determined in terms of driving-point-impedances ( $Z_{11}$ ,  $Z_{11S3}$ ,  $Z_{22}$ ,  $Z_{11S2}$ ,  $Z_{44}$ ,  $Z_{44S3}$ , and  $Z_{44}$ ,  $Z_{44S2}$ ) at each port as defined by Cutkosky. These impedances have been measured by the Agilent's E4991A impedance analyzer from 1 to 200 MHz. The inductive components of EECM have been determined using circuit theory. The capacitive components of EECM are measured directly at 1 kHz using GR1616 precision capacitance bridge. The resonance frequency of each driving-point-impedance has been measured using impedance analyzer. The four driving-point-impedances ( $Z_{11}$ ,  $Z_{11S3}$ ,  $Z_{22}$ ,  $Z_{11S2}$ ) are sufficient to produce four equations with four unknown inductive-components. These unknown inductive-components are thereafter determined as a function of frequency with the help of measured capacitive-components of EECM and resonance frequency of driving-point-impedance. The inductive and capacitive components of the EECM will be used to estimate the frequency characteristics of 4TP capacitance standards at higher frequency.

**Keywords:** Capacitance Standard, Resonance Frequency, Electrical Equivalent Circuit, Impedance

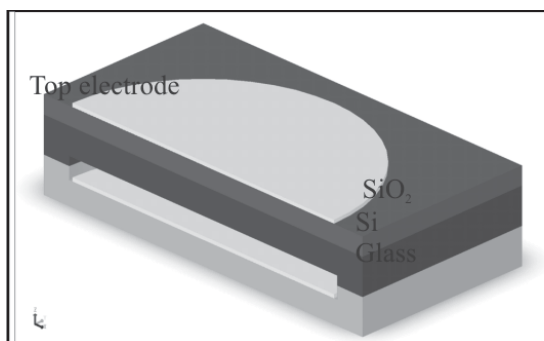
## Design and Simulation of CMUT Cell for Medical Applications

R. Mukhiya, A. Sharma, Aditi and V. K. Khanna

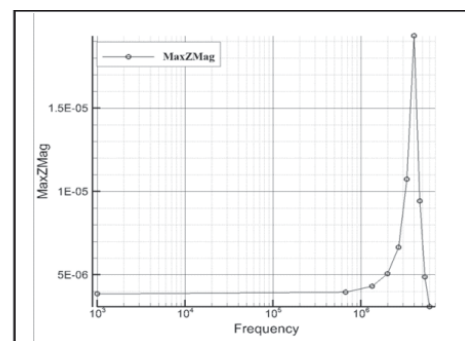
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### Abstract

Broadly, the ultrasonic transducers can be categorized based on the transduction mechanism such as piezoelectric ultrasonic transducer and capacitive ultrasonic transducer. So far, research has been carried out mainly towards the development of piezoelectric ultrasonic transducer. Recently, capacitive ultrasonic transducer has attracted attention, due to its less stringent requirement on the impedance matching, ease of integration, high sensitivity, wide bandwidth and capability of operating at high temperatures. In view of these advantages, the present research aims at developing MEMS-based miniaturized capacitive micromachined ultrasonic transducer. Ultrasonic transducers have wide applications in industry, medical, automotive and consumer electronics. In this context, the primary goal of the work is to design and develop a complementary metal-oxide semiconductor (CMOS)-compatible CMUT process and technology. Nevertheless, it is always desirable to integrate electronics with the sensor microstructures on the same chip to develop smart sensors. The research work includes finite element method (FEM)-based design and simulation of CMUT to be realized by wafer bonding techniques for medical applications. Depending on the organ to be diagnosed, the resolution and thereby the resonance frequency of the CMUT varies. Presently, the CMUT design is for the abdomen diagnosis, which requires the resonant frequency to be in the range of 2-7 MHz. Structure of the CMUT cell considered in this design is shown in Figure 1. The shape of the membrane is circular. It is made of silicon ( $\sim 1 \mu\text{m}$ ) and silicon dioxide ( $\sim 1 \mu\text{m}$ ), with gap of around  $\sim 1 \mu\text{m}$  between the electrodes. Top and bottom electrodes are of Ti/Cr + Au on top of the membrane and on the glass substrate. FEM simulations were carried out using CoventorWare®, and resonant frequency was found to be  $\sim 3.5 \text{ MHz}$ , as shown in Figure 2.



**Fig. 1:** CMUT structure.



**Fig. 2:** Frequency response of CMUT structure.

**Keywords:** CMUT, Ultrasonic Transducer, MEMS.

## Measurement of Linear Thermal Expansion Coefficient of Metallic Bar Using Grating Shearing Interferometry

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### Abstract

An innovative technique for the measurement of linear thermal expansion coefficient of metallic bar using grating shearing interferometry is reported in this paper. Fig.1 shows the experimental setup for the measurement of coefficient of linear thermal expansion of metallic bar using grating shearing interferometry. Light from the unexpanded laser is spatially filtered, expanded and collimated using a spatial filtering arrangement and collimating lens of focal length 250 mm. The collimated light passes through the beam splitter and illuminates the front surface of the specimen. The specimen is placed in a furnace, temperature of which is controlled using a PID controller. The back reflected light from the specimen is deflected through the beam splitter and is incident on the lateral shearing apparatus comprising of gratings G1 and G2 of the same period. The gratings in the interferometer are aligned

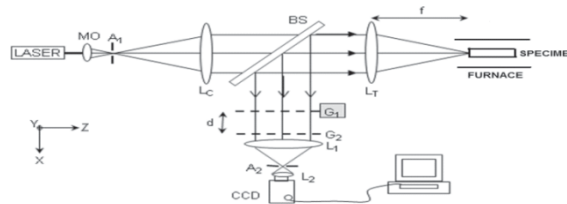


Fig. 1

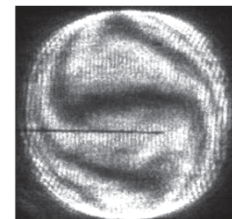


Fig. 2

so that grating lines of two gratings are parallel to each-other. In this condition, the uniform illumination in the field of view is obtained. When the test specimen was expanded along the z-direction, the reflected beam emerging from the test specimen is no longer collimated and each ray from the specimen is shifted; the shift being proportional to the thermal expansion of the specimen. Under such a condition, the fringes are obtained at the CCD (Charge Coupled Device) plane. Fig. 2 shows the interferogram obtained when the specimen is heated. For the automatic detection, recording, storage, and retrieval of data, the grabbing and retrieval system comprising of CCD and computer system has been used. The digital image processing technique is used for decoding the recorded data and for improvement of contrast of the recorded images. The results of the experimental investigation are influenced by factors such as the quality of optics used, imperfections in the mechanical components, aberrations in lens, detector non-linearity etc. Detailed uncertainty analysis to account for the above factors has been undertaken and reported in this work.

**Keywords:** Thermal expansion coefficient, Optical metrology, Characterization of material.

## Long-term Measurement of Ambient Ammonia and its Impacts on Air Quality of Delhi, India

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### Abstract

Ambient ammonia ( $\text{NH}_3$ ) has important environmental implications due to its role in ecosystem and global nitrogen cycle, as well as contribution to particle formation. In the present study, we report long-term continuous measurements of ambient  $\text{NH}_3$ ,  $\text{NO}$ ,  $\text{NO}_2$  and  $\text{SO}_2$  at an urban site of Delhi, India during January 2010 to December 2014, which provide temporal characteristics of ambient  $\text{NH}_3$ . In the present study, average mixing ratios of ambient  $\text{NH}_3$ ,  $\text{NO}$ ,  $\text{NO}_2$  and  $\text{SO}_2$  were recorded as  $17.1 \pm 3.2$ ,  $22.4 \pm 5.6$ ,  $12.4 \pm 4.2$ ,  $1.8 \pm 0.5$  ppb, respectively at Delhi, India. The positive correlation matrix between ambient  $\text{NH}_3$  and related water soluble ionic components of  $\text{PM}_{2.5}$  ( $\text{NH}_4^+$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$  and  $\text{Cl}^-$  etc.) indicated the possible formation of secondary inorganic aerosol over Delhi. In addition, we observed significant positive correlations between  $\text{NH}_4^+ / (\text{NH}_4^+ + \text{NH}_3)$  and  $\text{PM}_{2.5}$  mass concentrations, implying a contribution to gas-to-particle conversion. During study, we observed that the lower temperature and higher humidity favour the conversion of gaseous  $\text{NH}_3$  to particulate  $\text{NH}_4^+$  ( $\text{PM}_{2.5}$  mass) and particulate  $\text{NH}_4^+$  always lower than the gaseous  $\text{NH}_3$ .

**Keywords:** Ambient  $\text{NH}_3$ ,  $\text{PM}_{2.5}$ , Long-term

## Simulations of MOSFET Test Structures with Different Dielectric Films for ISFET Characterization

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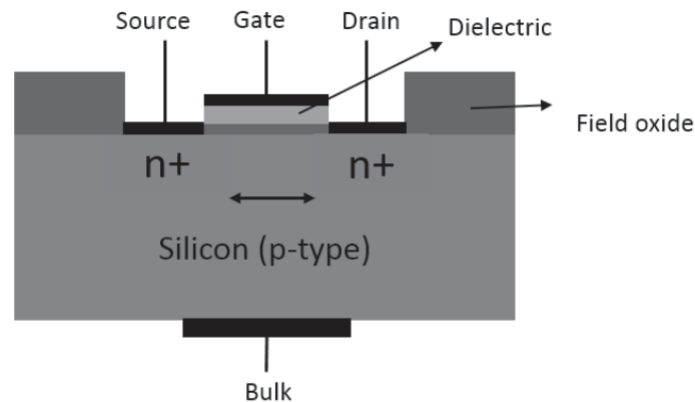
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### Abstract

High-k dielectric materials offer significant advantage of increased gate capacitance than the most commonly used silicon dioxide. In this paper, an n-channel MOSFET using high dielectric constant materials, viz.: Si<sub>3</sub>N<sub>4</sub>, AlN, Al<sub>2</sub>O<sub>3</sub>; was simulated to study its electrical characteristics. The simulations were carried out to predict the performance of ISFET, which is fabricated on same wafer. The performance of ISFET sensor was predicted using the behavior of MOSFET test structures. MOSFET device simulations were performed in Atlas™ to obtain the transfer characteristics (I<sub>d</sub> vs. V<sub>gs</sub>) and output characteristics (I<sub>d</sub> vs. V<sub>ds</sub>). The simulations of MOSFET test structures were carried out using same dimensions as ISFET devices and same thickness of dielectric films. High dielectric constant gate technology is a strong alternative for replacing the conventional SiO<sub>2</sub> dielectric in MOSFETs. High dielectric offers a solution to leakage problem that occurs at gate oxide as thickness is scaled down. The results show that as dielectric constant of film increases, the drain current increases. A variation in threshold voltage was observed with high-k sensing films over gate oxide. High dielectric film offers better sensitivity, lesser drift in pH applications and can be used for chemical & biological sensing applications.

**Keywords:** MOSFET, ISFET, Silvaco®.



**Fig 1.** MOSFET Structure

## Design and Analysis of MEMS-based Z-axis Capacitive Accelerometer

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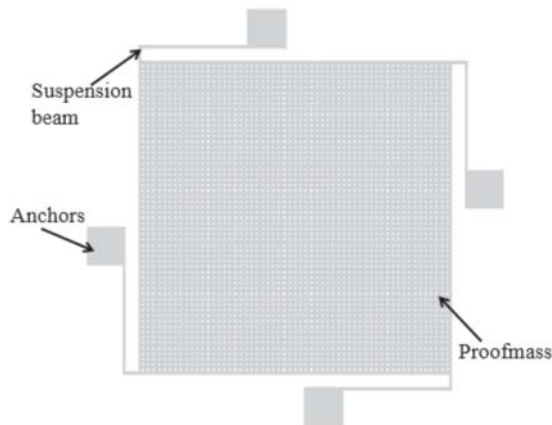
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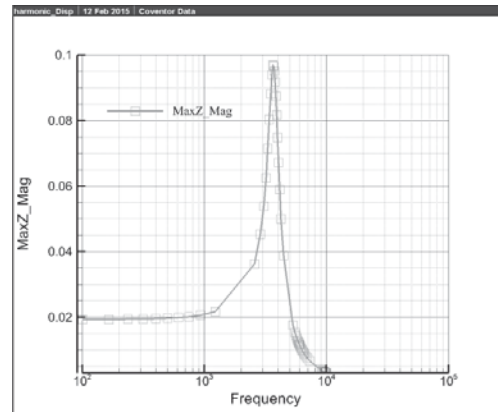
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### Abstract

In this paper, a MEMS-based Z-axis capacitive accelerometer is designed, analyzed and simulated. An out-of-plane Z-axis Capacitive accelerometer designed for an acceleration range of  $\pm 10g$ , to be fabricated using  $8\ \mu\text{m}$  UV-LIGA technology. The device was simulated with the help of MEMS CAD tool CoventorWare®. In modal analysis, resonance frequency of 3.1 kHz for out-of-plane mode was obtained. The operating voltage is 5V DC. Simulation results show good linear characteristics in the operating range of DC-400 Hz, which is the bandwidth of the accelerometer.



**Fig. 1.** Schematic of out-of-plane accelerometer



**Fig. 2.** Frequency vs. displacement on applying acceleration

**Keywords:** MEMS, Accelerometer, CoventorWare®, UV-LIGA.

## **Determination of Total Arsenic in Brown Rice Flour by High Resolution Inductively Coupled Plasma Mass Spectrometry-Result of APMP.QM-P21 Pilot Study**

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### **Abstract**

Contamination of arsenic in the environment at very low concentration also causes several diseases to human beings. It enters to human body probably by ingestion and inhalation, among which ingestion occurs mainly through water and food. Worldwide rice is being consumed as a staple food. Arsenic (As) can easily be taken up by rice plant through which it enters in the food chain. Determination of As in trace level is a challenging and difficult task due to its volatile nature. Thus reliable analytical results are required for compliance with international regulations and trade.

Recent past, NPL- India had participated in the APMP.QM-P21 pilot study on toxic elements in brown rice flour organized by National Metrology Institute of Japan. Five replicates of approximate 0.5 g rice sample were digested in microwave digestion system with 4 mL of nitric acid, 2 mL hydrogen peroxide and 0.1 mL of hydrofluoric acid. The aliquot had been prepared to the appropriate dilution by mass. The quantification of As was done by using fast scanning single collector sector field high resolution inductively coupled plasma mass spectrometry (HR-ICPMS, AttoM, Nu Instrument, UK). Internal standard of <sup>72</sup>Ge was used for drift correction for the analysis of <sup>75</sup>As. The aliquots had been prepared gravimetrically spiked with known concentration of <sup>72</sup>Ge. NIST SRM 1643e, multi elemental aqueous solution containing As was used for the calibration of HR-ICPMSs system. A reference material of fish sample is digested in duplicate along with the inter comparison samples for the recovery test for As. The evaluation of expanded uncertainty in measurement of total As was done at 95% confidence level (k=2) according to EURACHEM GUM GUIDE. The concentration of total As in the brown rice flour reference material is found to be 0.29 mg/kg which is close agreement with the reference value. The associated measurement uncertainty obtained is less than 3 %.

**Keywords:** Arsenic, Rice, Pilot study, High Resolution, Mass spectrometry



## **Studies of Short term satiability of convectron vacuum gauge**

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### **Abstract**

Present paper describes studies carried out on an industrial convectron vacuum gauge for a short term period. A study was carried out on industrial convectron pressure measurement gauge tube sensor. It is the popularly known as upgraded version of Pirani gauge and widely used in industrial establishment. Industrial convectron gauge is capable to measure pressure from atmosphere to  $1 \times 10^{-4}$  Torr and are used for roughing and foreline pressure measurement. The gauge under calibration is calibrated against secondary vacuum standards i.e. Capacitance Diaphragm gauge (CDG), Spinning Rotor gauge (SRG) and Digital Pressure indicator (DPI). We have performed the fine calibrations starting from 2009 to 2013, annually. The stability of the gauge is studied by comparing the calibration factor of the gauge over the years. A small change was observed during the 5 years of successive yearly measurement. Results were well within their claimed manufacturer uncertainties in the short term stability.

**Keywords:** Calibration, Measurement, convectron

## Uncertainty Evaluation of Recently Developed Prototype Water Flow Calibration System at NPLI

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### Abstract

In order to provide low-cost solution for Indian industries, NPLI has recently developed a prototype water flow calibration system of size DN100 (a mid size facility between DN50 and DN200) as per ISO 4185 standard. The system is comprising of different parts / devices like weighing tanks, load cells, pressure indicator, temperature sensor (with indicator), flow control valve, electromagnetic flowmeter, drain valves, diverter, flow nozzle, fishtail, pumps, constant level overhead tank, etc. The present paper describes the efforts made to identify different sources of measurement uncertainty and their evaluation process in a single and double weighing methods. The major error and uncertainty components thus identified are collected mass, collection time and water density. The error and uncertainty of the collected water mass depends on the balance indication, balance drift, balance calibration, buoyancy correction, leaks and splashes, storage effects and the evaporation. The error and uncertainty of the collection time depends on the timer calibration, timer actuation and the diverter error. The error and uncertainty of density depends on the accuracy of the density meter, quality of tap water and temperature of water used as flow medium. The Type A uncertainty associated with DUC flow meter will have to be included separately. The volume flow rate uncertainty associated with water flow measurements thus evaluated using this system at 1000 kg, 1500 kg and 2000 kg collected mass are  $\pm 0.055\%$ ,  $\pm 0.053\%$  and  $\pm 0.052\%$  respectively at  $k=2$ . In comparison to single weighing, a second weighing tank is required for increasing the collected mass and collection time for improvement of measurement error and uncertainty. Therefore, in a double weighing tank approach, the PC clock along with universal counter is used for collection time measurement for improving measurement error and uncertainty. The measurement results thus obtained are described in details.

**Keywords :** Uncertainty, collected mass, collection time, volume flow rate, mass flow rate, diverter error.

## Calibration of an Air Flow Calibrator using Recently Established Gas Flow Calibration Facility at CSIR-NPL, India

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### Abstract

National Physical Laboratory, New Delhi (NPLI) is the National Metrology Institute (NMI) for India and is responsible for establishment, maintenance, upgradation and dissemination of National Standards of Measurements. The group has Water Flow Calibration Facility and Water Meter Testing Facility. Recently, Gas Flow Calibration System (GFCS) based on laminar flow elements and sonic nozzles has been established in the Fluid Flow Measurement Standard group of NPLI in the flow range from 10 sccm (standard cubic centimeter per minute) to 1100 slm (standard litre per minute) referenced to 0°C and 101.325 kPa. The expanded measurement uncertainty of the system in the above flow range is  $\pm 0.2\%$  at  $k=2$ . The flow rate lower than 10 sccm is also available with higher uncertainty. This system has been established keeping in view the requirement of in-house users of NPL such as Chemical Metrology group, Radio and Atmospheric Science Division, Solar Energy group, etc. and external users such as Pollution Control Boards, pharmaceutical industries, petrochemical industries, environmental monitoring equipment manufacturers, R&D laboratories, NABL accredited laboratories, gas flow meters (mass flow controllers, mass flow meters, rotameters, digital flow calibrators) manufacturers, aerospace industries, etc. This system is used for calibration of different types of flowmeters such as mass flow controllers, mass flow meters, rotameters, totalizer type meters, digital flow calibrators, compact provers, etc used in many research, development and industrial applications mainly process controls, environmental monitoring, pharmaceuticals and drugs manufacturing, health assessment etc. and also in many NABL accredited laboratories. Present paper describes the details of the GFCS and calibration of a air flow calibrator (i.e. volumetric flow rate device) as a case study. The uncertainty has been estimated as per ISO 'GUM' document guidelines [1]. The standards used for calibration are traceable to appropriate "National standards".

**Keywords:** Gas flow calibration system, uncertainty, national metrology institute (NMI), laminar flow element, sonic nozzle, volume flow rate, mass flow rate.

## Capacitive & Resistive Load of an Ion Trap Affecting Systematics of Trapped Ions in it

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### Abstract

We are developing single trapped ytterbium-ion ( $^{171}\text{Yb}^+$ ) based optical frequency standard to achieve more accurate frequency standards than the cesium atomic fountain clock. A precision ion trap, mounted inside an ultra high vacuum environment, is needed to trap a single ion. We plan to use an end cap type Paul trap geometry. It consist a pairs of a solid inner electrode surrounded by a hollow cylindrical outer electrode, both mounted on holders for placing the electrode pairs facing each other. Dimensions of the parts are critical to  $\sim 20$  micron to achieve quadrupole trapping potential. A high amplitude rf at  $\sim 10$  MHz will be supplied to the inner electrode and a small dc will be fed to the outer electrode. The capacitive load, which shifts the resonance frequency, needs to be estimated for delivering desired rf to the trap. On the other hand effective individual capacitance on two opposite electrodes will introduce rf phase difference on them. That will result to extra micromotions and hence 2<sup>nd</sup> order Doppler shift to the precise frequency measurement. The sources of the capacitances are as following: low density air spaced inner and outer electrodes, two air spaced outer electrodes facing each other, two air spaced inner electrodes facing each other, inner electrode facing the opposite outer electrode, inner and outer trap holder separated by air and the inner and outer trap holders separated by macor spacer. The total resistance is contributed by the highly conductive electrodes and holders. The total resistance contributed by the holders and electrodes is few micro-ohms. An equivalent series resistance (ESR) of few ohms is contributed by the macor spacers in the ion trap assembly. All the capacitances are being calculated using both analytical and numerical techniques. There are various numerical techniques to calculate the capacitances as for example, Method of moments (MoM) and finite element methods (FEM). Here Method of Moments has been used. The numerical and analytical values differ from each other by approximately 3% which is below desired accuracy of our estimation. The capacitances which arise due to macor as dielectric have real capacitances including ESR which have been calculated using the loss tangent value of the dielectric. Remaining all the capacitances are very near to their ideal values as the trap will be in an ultra high vaccum chamber giving a relative permittivity equals to 1 in the chamber environment. This work and their relevance in building an accurate frequency standard will be presented in the meeting.

**Keywords:** Paul Trap, Method of Moments, Frequency Standard.

## Energy Shifts and Magic Wavelength of Yb+1 Clock Transition

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### Abstract

Atomic Clocks based on forbidden transition in optical frequency region have reached fractional uncertainty of the order of  $10^{-18}$ . Ytterbium-ion have three highly forbidden transitions, two of them are quadrupole transition  $6s\ ^2S_{1/2} \rightarrow 5d\ ^2D_{3/2}$  (435.5nm),  $6s\ ^2S_{1/2} \rightarrow 5d\ ^2D_{5/2}$  (411nm) and other one is octupole transition  $6s\ 2S_{1/2} \rightarrow 4f136s2\ 2F7/2$  (467nm), that can be used for frequency standards. Dominant sources of systematic uncertainties in Yb-ion arise from DC Stark shifts, Light shifts and BBR shifts which are directly proportional to polarization of the states associated to the clock transition. The shift results from interaction of the external dc electric field or electromagnetic wave with the atomic states and the exact coupling occurs in a complex manner. For calculating these couplings we calculate the electric dipole (E1) matrix elements using couple cluster method that couples to the associated states of the clock transitions. For that we use available experimental spectroscopic information. After getting the E1 matrix elements we calculate static and dynamic polarizabilities which has contributions from core of the atom, valence electrons and core-valence interactions. We assume a linearly polarized light hence the static and dynamic polarizabilities have scalar and tensor components only and the vector part cancels out. Static polarizability of  $6s\ ^2S_{1/2}$  ground state is  $(8.368 \pm 0.2422) \times 10^{-40}\ \text{Jm}^2/\text{v}$  and the dynamic polarizability is  $(21.51 \pm 0.3514) \times 10^{-40}\ \text{Jm}^2/\text{v}$  at the wavelength 435.5 nm and  $(28.11 \pm 0.5441) \times 10^{-40}\ \text{Jm}^2/\text{v}$  at the wavelength 411 nm. Static scalar polarizability of the  $5d\ ^2D_{3/2}$  and  $5d\ ^2D_{5/2}$  excited metastable states are  $(17.57 \pm 1.261) \times 10^{-40}\ \text{Jm}_2/\text{v}$  and  $(13.50 \pm 1.063) \times 10^{-40}\ \text{Jm}_2/\text{v}$ , respectively. Static tensor polarizability for these states are -  $(12.25 \pm 0.4426) \times 10^{-40}\ \text{Jm}^2/\text{v}$  and -  $(11.57 \pm 0.3942) \times 10^{-40}\ \text{Jm}^2/\text{v}$ , respectively. Dynamic scalar polarizability and tensor polarizability for  $5d\ ^2D_{3/2}$  state is  $(2.88 \pm 1.05) \times 10^{-40}\ \text{Jm}^2/\text{v}$  and -  $(4.08 \pm 1.51) \times 10^{-42}\ \text{Jm}^2/\text{v}$ , respectively at the wavelength 435 nm. Whereas the same for the  $5d\ ^2D_{5/2}$  states are  $(1.94 \pm 1.07) \times 10^{-40}\ \text{Jm}^2/\text{v}$  and  $(2.72 \pm 0.245) \times 10^{-41}\ \text{Jm}^2/\text{v}$ , respectively, at the wavelength 411 nm. We also obtain frequency dependent dynamic polarization of the  $6s\ ^2S_{1/2}$  and  $5d\ ^2D_{3/2}$  states over a wide range of frequency. At some particular frequency of the electromagnetic radiation energy shift for both of the states cancel each which is known as magic frequency (inverse of it is magic wavelength). We calculate magic wavelength for metastable clock transition  $6s\ ^2S_{1/2} \rightarrow 5d\ ^2D_{3/2}$  and these are 354.74 nm, 193.95 nm, 164.37 nm. Among these wavelengths only 354.74 nm magic wavelength is useful for trapping ion in optical lattice. We propose to trap Ytterbium-ions in an optical lattice prepared out of lasers at that magic wavelength. Hence we will be able to probe multiple ions which might be suitable for building next generation commercial atomic clock in chip traps with accuracies on the order of  $10^{-15}$ , or forming qubits for quantum computers.

**Keywords:** Polarizability, magic wavelength, optical lattice, atomic clock.

## Sound Insulation Metrology of Transmission Suite of CSIR-NPL

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### **Abstract**

The acoustical measurements were made in the suite of sound transmission (i.e. reverberation chambers) of CSIR-NPL. All tests of wall specimens are mounted in a removable test frame between two chambers, without rigid contact to either reverberation chamber. Tests were conducted in accordance with the requirements of ASTM E90, and of ISO 140/III 1995. In presenting and evaluating the results of measurements, three basic aspects will be considered: (i) Repeatability of sound transmission results when specimens are replicated with nominally equivalent materials, (ii) The effect on the sound transmission results due to modifications to the test facility; and (iii) The design of the measurement and the analysis of the experimental results to provide a basis for accurate estimates of the effect of specific changes in specimens.

This paper presents information primarily on the first two of these issues. All three are addressed further on analysis of results.

**Keywords:** Sound transmission loss (TL), Transmission suite, Repeatability, Sound transmission class (STC).

## Measurement of Contact Angle and Meniscus Shape using Moiré Deflectometry and Fourier Fringe Analysis

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### Abstract

Measurement of the contact angle between a solid surface and liquid, and the liquid meniscus shape is of importance in characterizing the liquids. In present communication, we report non-invasive measurement of contact angle meniscus shape of liquid using Moiré deflectometry and Fourier transform method. For the measurement of meniscus shape of liquid, spatially filtered collimated light from the He-Ne laser (wavelength 632nm) is incident onto a beam splitter as shown in Figure-1. The deflected light from beam splitter illuminates the liquid surface. Silicon oil has been used as a reference liquid. The back-reflected light from the top surface passes through the beam splitter and is incident onto a set of two identical gratings of period 0.04mm each, separated by a distance of 20mm. An aperture is used to separate the needless diffraction orders. Ultimately, the first order spot is allowed to pass and resulting superposed beams (fringe pattern) are focused onto the phase plate of the CCD camera. The recorded fringe pattern is used for further analysis. Towards this, Fourier transform method has been developed in Matlab environment to determine the phase. The Fourier transform method involves undertaking FFT (Fast Fourier Transform) of the recorded data, design of suitable digital filters to select the desired frequency spectrum and shifting it to the centre. Undertaking the inverse Fourier transform the phase of reflected wavefront is determined. From the phase data, the information regarding meniscus shape and contact angle is decoded. Good agreement between theoretical and experimental investigation has been achieved. Detailed error and uncertainty analysis has also been undertaken. The values of precision (standard deviation) achieved by the proposed method conforms to the uncertainty of measurement.

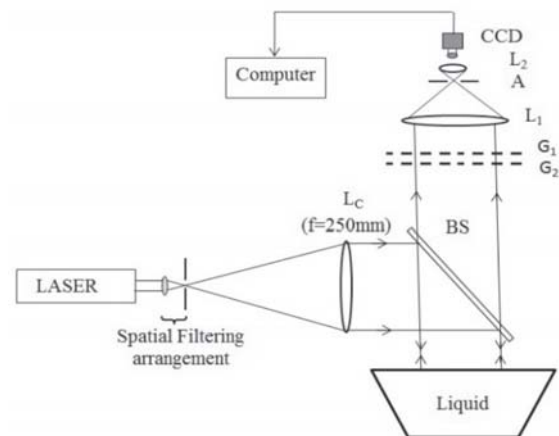


Fig. 1

**Keywords:** Meniscus shape, Optical metrology, Moiré deflectometry, Fourier transform

## Design Study for Cutting Force Measuring Dynamometer

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### Abstract

Force measurement is essential requirement in metal cutting as it is related to machine part design, tool design, power consumptions, vibrations, part accuracy, etc. It is the purpose of the measurement of cutting force to be able to understand the cutting mechanism such as the effects of cutting variables on the cutting force, the machinability of the work piece, the process of chip formation, chatter and tool wear. For over 100 years, metal-cutting researches attempting to understand the cutting behaviour better have investigated the cutting forces in metal cutting. It has been observed that the force values obtained by engineering calculations contain some errors compared to experimental measurements. Since the undeformed chip thickness and the direction of cutting speed vary at every moment, cutting process generally is geometrically complex. Owing to such complexity, the cutting forces even in steady-state conditions is affected by many parameters and the variation of cutting force with time has a peculiar characteristic. The need for measurement of all cutting force component arises from many factors, but probably the most important is the need for correlation with the progress of tool wear. In a three-dimensional cutting operation, three force components are necessary, whereas while drilling or tapping, only a torque and thrust drill are required. The strain gauge produces a clear relation between the measured quantity and the strain on a suitable spot on the spring element. In most cases, the static force is obtained by a strain gauge type sensor which produces an output voltage proportional to elastic deformation. The cutting force dynamometers must be manufactured at sufficient accuracy and high rigidity, and particularly suitable for dynamic loads. In designing the dynamometer, some principles such as parallel beam type, circular hole, piezo-electric, etc., have been used widely. In comparison of the piezoelectric sensors, semiconductor (silicon) strain gages and strain gages, the desirable features of piezoelectric sensors include their rugged construction, small size, high speed, and selfgenerated signal. On the other hand, they are sensitive to temperature variations and require special cabling and amplification. The rigidity and sensitivity are two opposing but basic requirements in dynamometer design. In addition, the structure of the dynamometer has to meet more strict requirements concerning the natural frequency and wide frequency response and small cross-sensitivity.

**Keywords:** Cutting Force, Strain Gauge, Force Measurement, Dynamometer.



## **A Terse Review of Strain Gauge Type Pressure Transducers**

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### **Abstract**

Pressure is one of the most important thermodynamic process parameters and is measured in process industry and other scientific and engineering applications of prime importance. There are varieties of sensing devices used to measure pressure in terms of an electrical output proportional to applied pressure. Strain gauge type sensing devices are the most common used in the pressure transducers because of their unique set of operational characteristics, ease in availability and cost effective nature for the last 4 decades or so. Due to variety of strain gauge pressure transducers commercially available in the market, it is always a complex choice for the consumer to select for the good one according to their requirements. The present paper describes the critical review of the strain gauge type pressure transducers. The review of the strain gauge pressure transducer starts from the historical background, type of strain gauges, measurement ranges, minimum required specifications, optimum precision and accuracy, recent advancement, advantages, limitations and finally choice criterion. Efforts made towards the analytical simulations carried out for development of a high precision high pressure transducer in the pressure range up to 200 MPa is also described.

**Keywords:** Strain gauges, Pressure transducer, Sensing devices

## Effect of Crop Residue Burning on Pulmonary Function of School Children in Rural Areas of Punjab

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### Abstract

To assess the effects of air pollution associated with crop residue burning on pulmonary functions of school children, pulmonary function tests (FVC, FEV<sub>1</sub>), Blood pressure (BP) and Oxygen Saturation (SpO<sub>2</sub>) level of 172 healthy school children between the age group of 9-15 years in Sangrur, Fatehgarh Sahib and Patiala, located in Malwa region of Punjab, were done twice every month between September 2014 and November 2015. Concentration levels of PM<sub>1.0</sub>, PM<sub>2.5</sub> and PM<sub>10</sub> were measured using portable Aerosol Spectrometer and for Pulmonary Function Tests, spirometers were used. The airborne PM concentration was higher in rice crop burning period as compared to wheat crop burning period with concentration of PM<sub>1</sub> reaching up to maximum of 247, 186 and 157  $\mu\text{gm}^{-3}$  in the indoor classroom air of Patiala, Fatehgarh Sahib and Sangrur site, respectively, during the month of October in 2015. PFTs undergo a significant decrease during the same period in their respective values. Effect of Agriculture Crop Residue Burning (ACRB) on the Force vital capacity is more than that on Force expiratory volume in 1 second, which had a delayed effect on pulmonary functions. The study shows that reduction in lung functions (FVC and FEV<sub>1</sub>) can be attributed to higher particulate matter concentration in ambient air during the local crop residue burning episodes.

**Keywords:** Crop residue burning, RSPM, Aerosol spectrometer, Spirometer, Pulmonary function test.

## Significance of Calibration of Reference Sub- Standard Energy Meter and its Maintenance

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### Abstract

In Power Distribution networks, Energy Meters play important role in revenue realization for Utilities. They form a link between the consumers and utilities. Inaccurate registration of energy leads to financial losses either to consumers or utilities. Reliable billing depends on the reliability of Energy meters. To prove their reliability Energy Meters must be checked for its accuracy by portable meters known as reference sub-standard (RSS) meters. These RSS meters are used both at the testing laboratories(for Type test/Acceptance test/Routine test) and at site to check Energy Meter performance without disconnecting load or to attend the consumer complaints. Based on RSS meter result the accuracy of Energy Meter is evaluated. Therefore it is very much important that these RSS meter must be calibrated periodically before being used at lab or at site. This paper deals with the significance of calibration of RSS energy meter and its maintenance.



**Conclusion:** If the % error in DUC is more than the accuracy class it indicates dry soldering in the circuit, improper maintenance/handling of equipment, improper cleaning of CTs, damage due to vibration during transport etc.

**Keywords:** Reference sub-standard(RSS), Device under calibration(DUC), Accuracy class, LT/HT accuracy meter.

## Effect of Filler Particle Size on the Surface Properties of Linear Low Density Polyethylene (LLDPE)-Si Polymer Nanocomposites

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### Abstract

The present work is focused to enhance the surface properties of LLDPE-Si nanocomposites, making them more suitable for piping applications. Viscous shear stresses within the liquid and friction along the pipe walls create resistance to flow within a pipe. This resistance results in a pressure drop or loss of head in the pipes. Surface roughness of pipes plays an important role in controlling the energy losses of fluid flowing through them. Although previously, numbers of studies have been conducted in order to enhance various mechanical properties such as hardness, density, tensile strength and thermal stability of linear low density polyethylene-Si nanocomposites but the surface parameters are not studied up-to a good extent. In the present study, silica nanoparticles are infused in linear low density polyethylene (LLDPE) matrix in order to prepare different series of polymer nanocomposites, primarily to be used in piping applications. The silica nanoparticles of different sizes (ranging from 20 nm to 145 nm) are synthesized by using probe ultrasonication technique. To make experimental samples, same weight fraction (3%) of differently sized silica nanoparticles is reinforced with linear low density polyethylene. The surface texture study of these samples is done by using a 3 dimensional noncontact optical profiler [Fig.1], which shows that various surface parameters such as average surface roughness, root mean squared surface roughness, ten point mean surface roughness and maximum peak height of the profile increase with decrease in filler particles size.

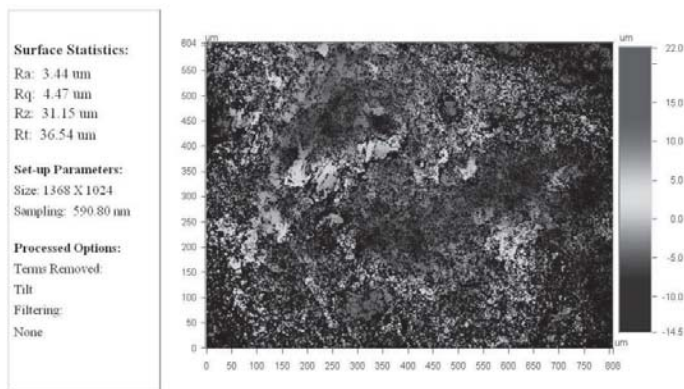


Fig. 1: Surface roughness of LLDPE-Si nanocomposite

Thus by infusing suitable size of silica nanoparticles in linear low density polyethylene matrix, we can achieve different combinations of surface roughness and other mechanical properties resulting into the development of some promising pipe materials with lesser piping losses and longer life. In this paper we report the measurement of roughness parameters of LLDPE-Si nanocomposites and we plan to discuss the uncertainty associated.

**Keywords:** Surface property, Roughness measurement, Nano composite

## Control & Data Acquisition System for Automation of the Optical Frequency Standard

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### Abstract

Any experiment using numerous instruments and electronic devices needs to be handled carefully in order to avoid human errors like inaccurate input, wrong sequential operation etc. But for a precision experiment which needs to be operated uninterruptedly and reliably over long period of time requirements are more critical. As in our experiment *i.e.* single trapped ion optical clock the constraints are also on remote control, coherence and time delays in the operation of these numerous devices. All these stringent requirements can be fulfilled by a computer operated control system which can be remotely operated (isolated from experiment), for addressing, controlling the inputs and acquiring data from the whole experiment. For this we are developing one such automated control and data acquisition system indigenously for use in our optical atomic clock. This system uses hardware and software modules such as workstation computer, peripheral component interconnect data acquisition card (DAQ, NI PCIe 6353), addressing module, digital buffer circuits, pair of 50 line flat ribbon cables (FRCs) for digital data and address, coaxial cables for analog data etc. and LabVIEW software. Traditionally used microcontrollers are not a good for tuning the parameters over a range. Here, each device has an addressing module associated with it which is addresses by the computer program enabling the device at that address and latching the digital data sent from computer. Up to 64 devices can be selected using 6 bit digital address and controlled using a 16 bit digital data travelling to the device from the DAQ in the computer. The devices are thus controlled remotely as they are near the experiment and the FRCs are spread all throughout the lab (~ 30 meters) to travel them. Devices like computer controlled dc power supply, AOM controller are already tested with this prototype system. Some more hardware parts such as digital buffers are currently under development. The entire scheme will be universal and can be incorporated for many other experiments, which will be presented.

**Keywords:** Automation, Data acquisition, Control system.

## Trends of Ozone, PM<sub>2.5</sub> and PM<sub>10</sub> and Their Correlations with Meteorology in Indo Gangetic Plains of India during 2014

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### Abstract

Fortnightly averaged levels of Ozone, PM<sub>2.5</sub> and PM<sub>10</sub> are presented along with meteorological parameters, carried out at an urban location, Patiala, in Punjab plain of Indo-Gangetic plain from December 2013 (FN-1) to November 2014 (FN-24). These observations were plotted to show trends of pollutants and meteorological parameters. The mean concentration of ozone, PM<sub>2.5</sub> and PM<sub>10</sub> over the entire study period were  $38.52 \pm 10.57$  ppb,  $88.08 \pm 54.96 \mu\text{g m}^{-3}$  and  $176.29 \pm 73.23 \mu\text{g m}^{-3}$ , respectively. The highest fortnightly averaged temperature of 38° C was recorded in FN-13 corresponding to the lowest relative humidity of 44%. Concentration profiles of PM<sub>2.5</sub> and PM<sub>10</sub> vary on similar patterns except for their magnitude. The relationship between atmospheric pollutants and meteorological parameters was studied using correlation analysis. Ozone showed a significant positive correlation with temperature, solar radiation and wind speed. PM<sub>10</sub> and PM<sub>2.5</sub> showed a significant positive correlation with each other and negatively correlated with temperature, solar radiation and wind speed. The fortnight maxima levels of ozone, PM<sub>2.5</sub> and PM<sub>10</sub> varied between 47-144 ppb, 83-673  $\mu\text{g m}^{-3}$  and 187-810  $\mu\text{g m}^{-3}$ , respectively.

**Keywords:** Surface Ozone, PM<sub>2.5</sub> and PM<sub>10</sub>, Meteorology, Correlation analysis

## Suitable Ion Trap with Reduced Systematics for Ytterbium-ion

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### Abstract

An Ytterbium-ion trap experiment for probing its highly forbidden ultra-narrow  $^2S_{1/2} - ^2F_{7/2}$  electric octupole transition at the wavelength 467 nm is under development at CSIR-NPL. This aims to build a precise secondary frequency standard with an accuracy few parts part in 10<sup>17</sup> which will also enable us to investigate temporal constancy of the fine structure constant or violation of local Lorentz invariance or non-conservation of parity. Since we are aiming for precision measurements, we have indigenously designed an ion trap with careful study of the systematics induced by the trap itself. In particular electric quadrupole and 2<sup>nd</sup> or Doppler shifts are discussed here. We have estimated the electric quadrupole moments  $\theta$  of the states associated to the clock transitions since the previous theoretical and experimental values differ by factor of five. Here we have obtained a  $\theta$  value of the  $^2F_{7/2}$  state which is comparable to other theoretical values but differs from the one and only experimental result. New measurements will be required for validation. Through numerical simulations we have identified a suitable trap geometry producing nearly ideal harmonic confinement which will allow us for a precise measurement of  $\theta$ . The trap and its vacuum assembly is designed such that the quadrupole shift will be cancelled below the projected accuracy of the frequency standard. The second order Doppler shift plays a significant role at this level of accuracy. The ions acquire excess micromotion due to phase difference  $\theta$  of rf at the two electrodes of the ion-trap, which induces significant 2<sup>nd</sup> order Doppler shifts. The differential capacitive and inductive loads at the electrode path are the sources of this phase difference which arise due to imperfect machining and assembling of the components associated to the trap. We have estimated effective loads resulting from individual trap components and their connections in our trap as well as from the entire assembly. These loads are used in an equivalent circuit analysis to estimate the effective  $\theta$  which depends on the achievable machining tolerance or assembling inaccuracy. In reverse, aiming for a fraction accuracy of 10<sup>-17</sup> the tolerable  $\theta$  is estimated to be 1/2<sup>o</sup> and assuming of a machining tolerance  $\pm 20$  micron we have identified a suitable ion trap design where the 2<sup>nd</sup> order Doppler shift is minimized. The subcomponents of the experiment, e.g., fabrication of the trap, vacuum vessel, optical systems, electronic modules and data acquisition system are currently under development.

**Keywords:** frequency standard, atomic clock, ion trap, precision measurement, systematic shifts.

## Determination of Pressure Distortion Coefficient of a Piston Gauge and its Associated Uncertainty - A Monte Carlo Simulation

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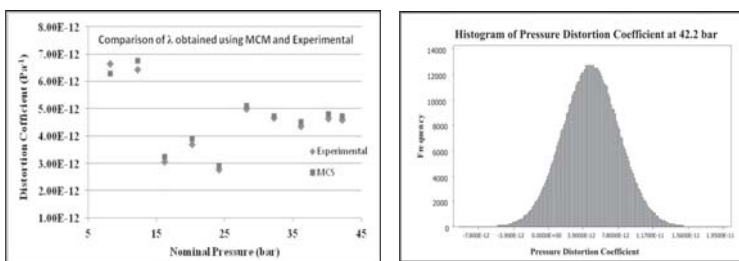
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### Abstract

This paper reports the evaluation of the pressure distortion coefficient ( $\lambda$ ) and its associated measurement uncertainty of a pneumatic pressure reference standard (NPLI-4) using Monte Carlo Method and its comparison with the experimental results. NPLI-4 was cross floated with pneumatic primary pressure standard which is a large diameter piston gauge (NPLI-P10). Experimentally, the distortion coefficient was calculated by least square fitting of effective area with the pressure and uncertainty estimation is carried out using JCGM 100:2008 guide and NABL 141. Monte Carlo method (MCM) was also used to determine the  $\lambda$  and its uncertainty. MCM relies on propagation of distributions while the conventional method of uncertainty computation relies on law of propagation of uncertainty (LPU). An attempt has been made to determine uncertainty using MCM and compared with the LPU method. The model equation used for the determination of Distortion coefficient was based on Dadson's model i.e.  $A_{\text{eff}} = A_0 (1 + \lambda P)$  for both experimental as well as MCM estimations, where  $A_{\text{eff}}$  is the effective area,  $A_0$  is the effective area at zero pressure and  $P$  is the pressure. For MCM,  $10^6$  numbers of trials are made, and the probability distribution of each input quantity is propagated through the model equation to find the output. At first, effective area of NPLI-4 was calculated using MCM, which is then fitted with the pressure to find the  $A_0$ . Random numbers were generated for the  $A_{\text{eff}}$  and  $P$  values, which are then propagated to find the  $\lambda$ . MCM gives directly the probability distribution function of the output quantity which may not always be normal as assumed in case of LPU according to the central limit theorem. The statistical information of output can be easily obtained from its PDF like estimation of output in the form of average; associated standard uncertainty in the form of standard deviation; coverage interval according to the desired coverage probability. The maximum relative deviation in  $\lambda$  between experimental and MCM values is found to be 5.8 % while the minimum is 1.8 % which is reasonably a good agreement.

**Keywords:** Pressure Distortion Coefficient, Monte Carlo Method, Pneumatic Pressures





## Development of VCO based Drivers for Frequency Modulation

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### Abstract

Modulation of phase and frequency of lasers are an essential and common practice in atomic molecular and optical physics experiments. Acousto-optic modulator (AOM) and electro-optic modulator (EOM) driven by voltage controlled oscillator (VCO) are widely used for controlling and modulating output frequencies of semiconductor diode lasers. AOMs are usually working for modulating laser frequencies by several hundred Megahertz, whereas EOMs are useful for modulating laser frequency in the range of several GHz. One of the critical issues about working with AOM and EOM is unavailability of good quality of the self drivers for those modulators. In CSIR-NPL we are developing drivers for AOMs and EOMs to achieve low phase noise and ultrastable laser frequency with wide range of tunability. The drivers are made with VCOs and applicable in the high frequency to ultra-high frequency region. Integrating VCOs output frequencies with AOM and EOM, laser frequencies can be modulated by few MHz to several GHz. When an AC signal is applied to the piezoelectric transducer of an AOM, it starts oscillating and produces sound wave which causes variable kind of refractive index of the medium and leads to scattering of the incoming light and interference pattern similar to Bragg diffraction occurs. The incoming light passes through the AOMs will be Doppler shifted by the amount equal to the frequency of sound wave. On the other hand in EOM electro-optic effect is used to modulate the phase, frequency and amplitude of light beam. The main element of these drivers is a VCO, an electronic oscillator circuit and its oscillating frequency can be tuned within certain range by changing its input voltage. This tuning voltage is controlled with a 12 bits input digital to analog converter (DAC) and the output of the DAC is connected to a differential amplifier. The output RF frequency of the VCO is connected to a pre-amplifying stage through an attenuator and finally a broad band amplifier is used for generating 1-2 watt output power for driving the AOM and EOMs. An attenuator will control the output signal of the VCO and finally feed the signal to another amplification unit before sending it to the optical modulator. The input voltage of the VCO can be tuned to generate desired RF frequency from the VCO and the RF power can be controlled with the combination of the attenuator and amplifiers. While generating such a high frequency with VCO instability in the output frequency may occur and we have designed a high performance phase locked loop (PLL) for stabilizing the output frequencies of the VCOs.

**Keywords:** Frequency modulation, VCO, Electro optic effect

## Utilization of Multiple Beam Interference for Optical Computing

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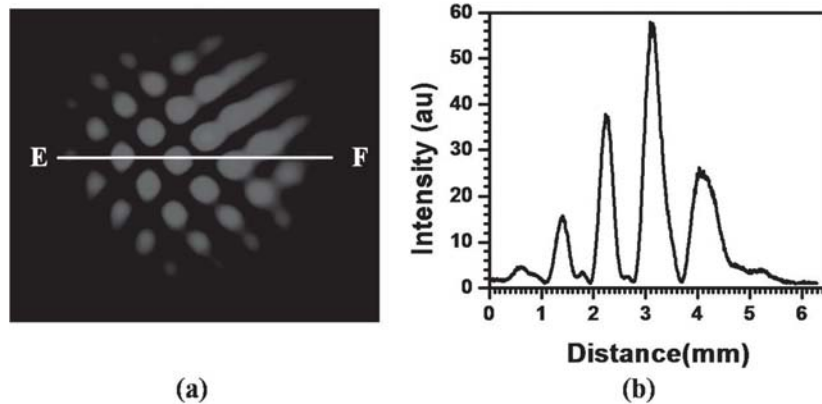
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### Abstract

This work reports the experimental realization of parallel optical logic gates and some combinational logic using multiple beam interference in three cascaded Michelson type interferometers. Considering light intensity at different points of 2-D interference pattern (Fig.1) of four input laser beams as output, (i) two input AND, OR, NAND, NOR, XOR, XNOR optical logic gates in parallel, (ii) three input AND and NAND optical logic gates in parallel, and (iii) four input AND logic gate as well as some combinational logic in parallel were realized. Ultrafast photonic information processing can be performed by utilizing present scheme in which parallel operation of large number of logic gates is demonstrated by controlling the four input laser beams electro-optically or all-optically using nonlinear optical materials having large nonlinearity and fast response time.



**Fig. 1:** (a) CCD-image of four beam interference pattern  
(b) intensity variation along the arbitrarily chosen line EF.

**Keywords:** Multiple beam interference (MBI), Michelson interferometer, optical logic gates, optical computing.

## **New Approach in Calibration of Tilt Tables Using Coordinate Metrology**

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### **Abstract**

Coordinate measuring machine (CMM) is an equipment having spatial (X, Y, Z) coordinate system and it offers the advantage of aligning the machine coordinate system with job coordinate system. The measured spatial coordinates on the work piece surface are further analyzed to determine the required parameters. By using Coordinate metrology, the tilt (inclination) of the tilt table can be measured by which accuracy of tilt tables can be evaluated. Generally tilt or inclination is measured by using angle measuring instruments like Autocollimator, Electronic Levels, Laser Interferometers etc. which are having the limitation of range of angle measurement. This Paper focuses on Tilt angle or compound angle measurement of tilt tables using CMM where there is no limitation in the range of measurement. The feature available in the Tilt Table for CMM measurement is top plane surface. Initially zero position of the Tilt Table is set on surface plate using the Electronic level for datum reference. The setup for measurement includes the Tilt Table assembly mounted on CMM Table, with axis of worm wheel in XZ & XY plane, the feature is in YZ plane. At zero position of Tilt Table (i.e. in Horizontal orientation), the table surface was aligned with CMM XZ & YZ Planes and at maximum tilt position other plane - XY was aligned. Angular movements in YZ plane shown by Digital Readout (Sensor) are compared with CMM readings and these are termed as Pitch Angle. The angle in other plane (XZ Plane) is unwanted movement and is called as Roll Angle.

**Keywords:** CMM, Calibration, Tilt/ Inclination, Tilt Table,

## Advanced NRW Algorithm based Low Loss Permittivity Measurement for Xn-Band Waveguide System

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### Abstract

A scattering (S-) parameter based transmission-reflection microwave measurement method to retrieve relative permittivity of low loss material, such as Teflon, has been performed. The method uses Nicolson-Ross-Weir (NRW) algorithm that works on raw scattering parameters to extract the permittivity value. The measurement of S-parameters is performed on a waveguide based setup for Xn-band frequencies (5.85-8.20GHz). The paper explains NRW algorithm in graphical manner along with the MATLAB code. Application of proposed method is to establish dielectric property measurement required for specific absorption rate (SAR) evaluation for different microwave frequencies band.

**Keywords:** Dielectric, NRW-algorithm, S-parameters, Specific Absorption Rate (SAR)

## Slope Measurement of PMMA Plates in Transmission Geometry using Moiré Deflectometry

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### Abstract

Slope is an important parameter in measurement science and technology. It has been used for determination of surface shape, curvature, material deformation and defect detection etc. Slope has been widely studied using various techniques in reflection mode, however only very few attempts have been made for mapping the slope pattern for transparent objects. In present communication, we report our investigations undertaken towards measurement of slope of transparent object of Poly Methyl Metha Acrylate (PMMA) plates/material using Moiré deflectometry in transmission geometry. Figure-1 shows the experimental setup. Light from He-Ne Laser is expanded and collimated using microscopic objective (MO) and collimating lens ( $L_c$ ), respectively. The collimated light is incident onto a set of two identical gratings. The transparent sample S was kept in-between the gratings. A circular plate of diameter 50mm and thickness 2mm was used as specimen. It was mounted using a specially fabricated mechanical mount such that the specimen was bound along the diameter. The results of the experimental investigation are recorded using Charge Couple Device (CCD) camera. The spatial filtering arrangement comprising of lenses  $L_1$ ,  $L_2$  and an aperture A was used to select the first order for recording purposes. The gratings  $G_2$  is rotated at an angle of  $2^\circ$  with respect to  $G_1$ , so as to obtain equispaced Moiré fringes parallel to the grating lines. On loading the sample diametrically along Y-axis, the fringe pattern gets modulated in response to the refractive index and thickness variation in the specimen. Figure-2 shows the recorded fringe pattern under loading of specimen with an amount of 0.5mm along diameter. Validation of experimental results with theoretical prediction provides good correlation. An error of 1.88 % was determined between the theoretical and experimental data. Detailed error and uncertainty analysis has also been undertaken.

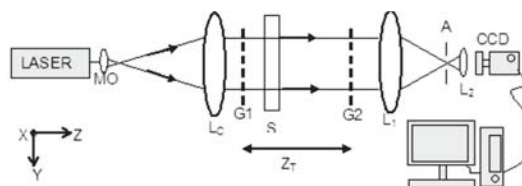


Figure-1



Figure-2

**Keywords:** Slope, Optical metrology, Moiré deflectometry, Interferometry

## Parallel Multiple Logic Operations using Multiple Beam Interference

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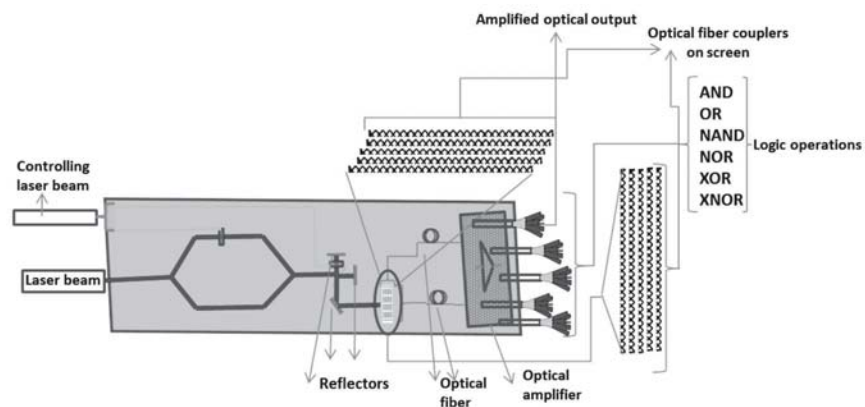
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### Abstract

An experimental study is conducted to realize feasibility of multiple parallel logic operations in as optical domain using multiple beam interference in cascaded Mach-Zehnder and Michelson interferometers. Considering light intensity at different points of 2-D interference pattern output, which is controlled by intensity of two input beams in the arms of Machzender and Michelson interferometers, respectively, two input multiple AND, OR, NAND, NOR, XOR and XNOR optical logic gate operations were demonstrated simultaneously. Further, a scheme was proposed to use these simultaneous logic operations, in designing integrated photonic circuits. Proposed scheme may have potential application in ultrafast information processing due to parallel multiple logic operations using the least number of electro-optic/all-optical switches. In the proposed scheme optical switches are used for ultrafast switching. A scheme for design of photonic chip is designed comprising interferometers, fiber couplers and optical amplifier is also proposed for multiple parallel logic gate operations as shown in fig 1.



**Keywords:** Multiple beam interference, optical parallel logic gates, optical/photonic chips.

## Investigation of Response of Load frequency Controller in Two Area Restructured System with Non-Linear Governor Characteristics

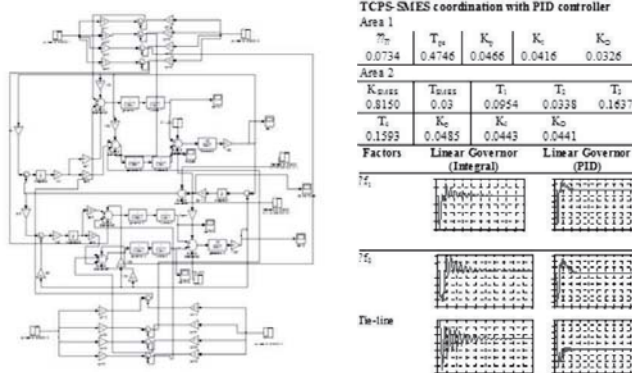
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### Abstract

The objective of automatic generation control (AGC) is to maintain the system frequency and tie line power flows of an interconnected power system within the scheduled values. Adaptive control of frequency has become more significant owing to increased size, complexity, sudden and unscheduled load perturbations and restructuring of power system. In this paper, a framework of automatic generation control with linear and non-linear governor characteristics in restructured power system has been presented. Conventional AGC with non-linear governor characteristics is reported to be dynamically unstable on account of low settling times. To stabilize the frequency and tie-line power oscillations, the frequency stabilizer equipped with energy storage system is modeled. Thyristor controlled phase shifter along with superconducting magnetic energy storage system (TCPS-SMES) are proposed and has resulted into an effective coordinated strategy against the varying system parameters particularly for tie-lines with low synchronizing coefficient. The parameters of frequency controller and energy storage system are tuned through a much acclaimed meta-heuristic technique coined as Genetic Algorithm. The transient response of optimized load frequency controller is simulated for two area system comprising non-linear hydro-hydro and hydro-thermal systems. The effectiveness of proposed frequency controllers are guaranteed by analyzing the transient performance of the system operating in deregulated environment. The optimized gains and parameters of the compensators provide less overshoot and minimum settling time with the help of PID controller in comparison to Integral controller.

**Keywords:** AGC, compensator, deregulation, energy storage, genetic, hydro., phase shifter, tie-line, transient,



## Investigation and Evaluation of Systematics in Primary Frequency Standard at NPL, India

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### Abstract

CSIR-NPL, India (NPLI) has developed its first Cesium atomic fountain (NPLI-CsF1) primary frequency standard (PFS). The indigenously developed fountain frequency standard is now fully operational and its frequency is being evaluated along with all the systematic and statistical uncertainties. NPLI-CsF1 is periodically evaluated with respect to TAI (International Atomic Time). The fountain frequency is compared with the Hydrogen MASER (H-MASER) which is contributing to TAI already and hence fountain frequency is traceable to TAI. The present experimental data confirms that fountain frequency is stable to few parts in  $10^{15}$  at less than one day averaging time.

It is now possible to run the fountain continuously for days without major interruptions provided the ambient temperature of the room is stable. Estimation of various systematic shifts to the fountain frequency is periodically done. The magnetic field is measured for each evaluation to estimate second order Zeeman shift. The temperature of the flight tube is monitored to calculate the blackbody radiation (BBR) shift. The gravitational red-shift is fixed and is calculated from the estimated height of the microwave cavity above the geoid. The collision shift is estimated by operating the fountain alternatively in high and low density of detected atoms several days. The frequency offset with respect to the atomic density is extrapolated to zero density in order to get the collision coefficient. Presently, we are investigating this bias more carefully as this one is one of the major contributor of the uncertainty budget of NPLI-CsF1. In this paper, present evaluation of NPLI-CsF1 with respect to TAI with detailed uncertainty budget and detailed measurement procedure of systematics are presented. During May 2013 to February 2014 total seven evaluation cycles were performed and the results were submitted to BIPM. On November 2014 BIPM accepted the results of NPLI CsF1 and published it in its monthly report, Circular-T. We are now performing rigorous evaluation of NPLI-CsF1 in order to contribute regularly to TAI.

**Keywords:** Laser Cooling, Cold Atoms, Systematic Uncertainty, Time Scale.



## Indigenous Development of 2<sup>nd</sup> Cs Atomic Fountain Clock

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### Abstract

There are only 12 working Cesium (Cs) atomic fountains all over the world which is the primary standard of Time & frequency. NPL India has also developed an atomic fountain named NPLI-CsF1 which is now fully operational. Its frequency is periodically evaluated and it got BIPM (International Bureau of Weights and Measures) acceptance as primary frequency standard in November 2014. Now we are establishing a second Cs atomic fountain with some novel techniques and new designs which enhances the accuracy of time measurement and increases the contribution of India in time measurement to TAI (International Atomic Time). The novel techniques which are going to be implemented in the second fountain, the new design of the 3D MOT chamber and the UHV (ultra high vacuum) assembly techniques will be discussed and presented in detail. To increase the signal to noise ratio and thus the accuracy of the frequency measurement a novel technique Optical pumping is going to be implemented in the second fountain. The theoretical calculations of the 25 level system by rate equation approach and further elaboration of these calculations by density matrix approach and its status will be discussed in detail. The design criteria of four feed microwave cavity which decreases the distributed cavity phase shift and its advantages will be discussed. The design of the 3D MOT (magneto optical trap) chamber which decreases the light shift in the frequency measurement will be discussed. And the extremely critical UHV and optical assembly techniques will be discussed. A novel technique of UHV viewport design and its assembly will be presented.

**Keywords:** Primary standard of Time & Frequency, optical pumping, 3d MOT, UHV assembly, microwave cavity

## Classification of Power Quality Events Using Radial Basis Function Neural Network

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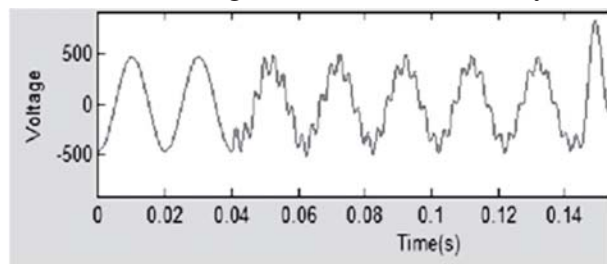
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### Abstract

Power Quality disturbances or events generated in power system are sag, swell, interruption, transient, harmonics, voltage imbalance etc. and they having very wide range of magnitude, time, frequency. For the sake of reliability of system, security of equipment's and availability of quality power to the end user, it is necessary to resolve such PQ events. For action taken to mitigate these PQ events, source and cause of disturbance must be known and this requires monitoring, identification and classification of disturbances. PQ problem are originated at generation point due to maintenance activity, unplanned scheduling, load transfers, short circuit and open circuit type of faults, by lightning (occurrence of spike or transient overvoltage), insulator flash over, transformer inrush current, improper operation of voltage regulation devices, flexible AC transmission system (FACTS) devices, corona, power line carrier signals etc.. Due to exploitation of various type of load such as switching of air conditioner, heavy motors, capacitor banks, sudden removal of heavy load etc. are major cause of power quality problems. The identification of PQ events can be judged on the basis of information regarding typical magnitude, duration, spectral content for each category of the signal and specification and limitations of IEEE and IEC standards. But effective detection based on fundamental inspection of waveform by human operators is laborious and time consuming and less accurate. A framework is desirable to automate the process of detection and classification in an intelligent and secured manner. Rule based expert system, artificial neural network, fuzzy classification, kernel machines, support vector machines and other sampling and evolutionary techniques for the classification of PQ events.

Artificial neural network has been realized as a suitable tool for identification and classification of PQ events. The neural network recognizes a given pattern by learning or training with a set of examples and these set of examples consist of input pattern along with level of classes. Radial basis function neural network (RBFNN) has been selected due to its universal approximation ability that can be used for the interpolation problem, its faster learning capability and more compact structure. For data mining, K-clustering technique is used. Pseudo inverse learning is proposed for updating weight of links between layers due to its simplicity in computation as compared to steepest descent technique. PQ event data (Training and testing data) is obtained using Simulink model of a system under various operating conditions due to disturbances like, short circuit type of fault, capacitor switching, heavy loadings, nonlinear loadings etc.. To insure the effectiveness of the RBF neural network model classification accuracy is measured, which is the ratio of the number of sampled data detected with respect to total number of sampled data. An average accuracy of 95.7% has been achieved in 100 epochs of 40 samples of data.



**Keywords:** Frequency, Neural, Power, Quality, Radial basis,

## **Progress towards Indigenous Development of a Hydrostatic Pressure Transducer in the Pressure Range up to 500MPa**

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### **Abstract**

The development of low cost high accuracy (0.5 % or better) pressure transducers in high pressure range up to 500 MPa is a challenge. The commercially available pressure transducers are very expensive. As a part of Make in India plan, we have made focused efforts to design and fabricate a pressure transducer in this range. The fabrication of the transducer is done adopting a unique design based on deformation in a tubular sensing element as a function of applied pressure. For the design optimization, we have also carried out the stress analysis on the sensing element using SolidWork 2014 SP1.0 software. The stress analysis clearly reveals that sensing element can sustain pressure up to 550 MPa or 1.1 times of working pressure range. After ascertaining the pressure sustainability of the sensing element, the strain gauges of 350 ohm were cemented on the sensing element in a full bridge, 2 each in longitudinal and radial directions to get maximum pressure sensitivity. The output of the pressure transducer in mV is recorded using digital multimeter. The pressure was then calibrated against national primary pressure standard at 11 equally spaced pressure points (0, 50, 100, 150, 200, 250, 300, 350, 400, 450 and 500) MPa. The 6 observations were taken at each pressure point which include, 3 each in increasing and decreasing orders of pressures thus making total 60 observations. The output of the sensor varies from 0 to 0.86 mV in the working pressure range. The results show an excellent linearity between pressure and recorded sensor output in mV having coefficient of determination  $R^2$  as 0.998. The progress made towards the development of a pressure transducer is reported in this paper.

**Keywords:** Pressure transducer, stress analysis, foil type strain gauge.

## Purity Evaluation of Chromium Chips by Gravimetric Method

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### Abstract

The industrial and technical importance of high-purity Chromium metal has been extensively used since many decades as catalyst, alloys mostly in the manufacture of stainless steel. In metrological point of view, the starting material of SI-traceable standards should be of very high quality. Gravimetric analysis is the primary method, which is required to determine the purity of the metal. In this study attempt has been made to evaluate the purity of chromium chips gravimetrically. A required quantity of chromium chips in five replicates were taken and dissolved with sub boiled hydrochloric acid and nitric acid. Further the solutions were treated with ammonium chloride and ammonium hydroxide to form chromium hydroxide. The precipitate formed were filtered, ignited and weighed in a calibrated balance. The purity of the chromium chips was evaluated and found to be 99.793 % with associated uncertainty 0.215 %. The evaluation of expanded uncertainty in evaluation of purity was done at 95% confidence level ( $k=2$ ) according to EURACHEM GUM approach.

**Keywords:** Purity, chromium, chips, gravimetric

## Long Term Stability of the Primary Torque Standard Machine Established at CSIR-NPL

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### Abstract

Torque is an important physical parameters which needs to be measured precisely as the application of torque plays a vital role in several industries such as mechanical, automobile, civil aviation, pharmaceuticals, etc.. Precision torque measurement is realized by applying dead weight force tangentially at one end of a lever arm having the other end firmly fixed to a suitable mount. We have established a torque primary standard machine consisting of a double sided lever supported on strain controlled elastic hinges, having a best measurement capability (BMC) of  $\pm 0.01\%$  in the 2-2000 Nm range. This primary machine is used to provide traceability in torque measurement the user industries. It is therefore important to monitor the measurement capability of the torque machine and also to participate in international inter-comparisons with other NMI in order to establish the stability of the performance of the machine over a period of time. In this paper, an effort is made to discuss the stability of this primary standard machine over a period of seven years. This helps us to maintain the degree of equivalence and also to build confidence on the claimed BMC (best measurement capability of the machine) of the machine. For this purpose, a precision torque transducer of 2000Nm capacity was calibrated on this machine in the clockwise direction using a standard calibration procedure based on BS 7882. The observed repeatability and reproducibility in the measured range changes from  $\pm 0.009\%$  to  $\pm 0.001\%$  and  $\pm 0.014\%$  to  $\pm 0.003\%$  respectively. The average calibration values are determined with the uncertainty associated in the measurement considering deviation due to resolution, repeatability, reproducibility, reversibility, interpolation and the uncertainty in the applied torque which is less than 0.03% over the range of 40-100% capacity of the transducer. The obtained average measured values are compared with the measurement data taken previously on the same transducer over a period of time.

The measured average values are also compared with the average values reported in the PTB, Germany certificate for the same transducer and with CCM TK1.1 key comparison results. From these measurements and analysis, it is observed that there is a slight increase in the average torque values measured by the transducer which could be attributed to the drift of the torque transducer values over the period of time. The small drift observed would not have any significant effect on the claimed BMC of 0.01% of the machine so performance of the machine is determined to be quite stable within the claimed limits. However, further investigation will be taken up in future to understand and monitor the stability of the machine after getting the artefact (i.e. 2000Nm torque transducer) calibrated again from PTB, Germany. This would enable us to analyse the characteristics and behaviour of the machine as well as the transducer with better clarity and understanding.

**Keywords:** Torque measurements, Calibration of Torque transducer, Primary torque standard

## **Novel Approaches for the Growth of Single Crystals by Bridgman Technique**

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### **Abstract**

In the recent past, the requirement of single crystalline materials is suddenly increased because of its numerous applications in different areas of research. Bridgman technique is one of the melt growth techniques and one can grow bulk size and good quality single crystals in the particular period of time. In this report, we are focussing for the growth defect free single crystal by altering the growth mechanism as well design of the ampoule which used for the growth. In this approach, we can enhance the quality of the single crystal and at the same time we can reduce the defect concentration. We have attempted to grow benzimidazole single crystal by using the ampoule support and found interesting results. We have compared the results with the crystal grown without any support. The support is giving slowly the heat to the grown single crystal and it is acting like a annealing. In other approach we have used the different crucible designs in order to encourage the single nucleation. We have grown the bismuth selenide single crystal and found enhanced crystalline perfection. The grown crystals were thoroughly characterized by PXRD, HRXRD, PL etc and the observed results will be presented in detail.

**Key words:** Single crystal, Bridgman, Crucible, Nucleation

## **An Inter-comparison Study between two Rockwell Hardness Standard Machines**

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### **Abstract**

Hardness is an important mechanical parameter needs to be precisely measured and expressed according to the internationally recognized scale for proper application of materials. It is highly desirable to optimize the hardness values of materials which play a vital role in our daily life particularly in machines wherever the moving parts in contact with one another is involved. The measurement of hardness values of materials is absolutely inevitable for the development of novel materials having potential applications in high technology industries like automobile, electronics, foundries, casing etc.

We have established the hardness standardizing machines in the Rockwell, Vickers and Brinell scales to provide necessary calibration and dissemination of the scales to the user industries. For performing these hardness measurements, we need to penetrate an indenter of a defined geometry onto a metal surface by applying a precisely known force for a specific interval of time. Thereafter, depending upon the hardness scale, certain dimensions of the indentation made by the indenter is measured and is express in universally acceptable number according to the standard procedure. In this paper we would like present the Rockwell hardness measurements performed using two different machines established at our laboratory on the HRA, HRB and HRC scales in order to achieve the degree of equivalence in the hardness measurements. For performing Rockwell hardness measurements, one requires to apply a preliminary force of 10kg to establish a datum line and then an additional test force of 50kg for HRA scales, 90kg for HRB scales and 140kg for HRC scales. These additional applied test forces are maintained for a specific duration time as defined in the standard procedure and then removed retaining the preliminary test forces. The depth of the permanent indentation made by the indenter on the hardness block is measured using a suitable measuring device and expressed in certain number called Rockwell unit.

For establishing the degree of equivalence of the machines, standard hardness blocks in different ranges are chosen on the HRA, HRB an HRC scales and the measurement was made on these standard blocks using the machines. As the mechanism behind the operations of the machines are different, the salient features of the machines are discussed with the repeatability measured by the machines. The deviations in average values measured by the machines are found to be within the acceptable limits of the uncertainties which are also compared with the standard block average values. The importance of the comparison study and the En ratios are discussed in this presentation.

**Keywords:** Rockwell scale, Hardness measurements, Primary hardness machine,

## Wet and Dry Deposition of Pollutants during Diwali Festival at Central Delhi

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### Abstract

The present study compares the ionic concentrations of major ionic species ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Cl}^-$ ,  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ) during day and night time in the dry and wet deposition during Diwali festival at Central Delhi. The study revealed that the effect of fireworks on dry and wet deposition was not long lasting. Though the impact of crackers was seen, the same pattern again maintained, thus pointing out that the settling velocity of all the episodic aerosols due to fireworks was also comparatively higher. Also, the results showed that the dry deposition was always higher than wet deposition for different components. Studies also indicated that the effect of humidity on the rate of sedimentation was not among the major factors as the deposition was more in day time than night time. All the studied ions almost showed the same trend except the nitrate ions that pointed that their formation was a light sensitive reaction- sunlight or firework display. Also, the deposition trend showed that the nitrate ions in the atmosphere were comparatively more hydrophilic than the other ions.

**Keywords:** Diwali festival, dry deposition, wet deposition, ionic species.



## Effect of Change in Acceleration of Gravity in Accuracy of Electronic Levels

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### Abstract

Electronic levels are generally pendulum type and use an electrical detecting system to sense the precise position of the pendulum with respect to the housing. These electronic levels are used for measurement of inclination. The absolute value of acceleration of gravity differs with geophysical position of the earth and hence angular displacement of pendulum in inclination measuring equipments changes accordingly. In the present study the effect of global variation of acceleration of gravity was studied in inclination accuracy measurement of electronic levels. The associated error with change of acceleration of gravity is estimated value to be 95.5756'' per 10° of inclination for change in acceleration of gravity values of 9.8059 m s<sup>-2</sup> and 9.7802 m s<sup>-2</sup> and experimentally found this error as 96°. Hence it requires the calibration and error adjustment of electronic levels at user's geophysical region in case these are manufactured/ calibrated at different geophysical regions.

**Keywords:** Inclination, acceleration of gravity, angular displacement, calibration, electronic level.

## **Cavity Ring-Down Spectroscopy Technique for the Impurity Analysis of CH<sub>4</sub> and H<sub>2</sub>O in Purity Nitrogen Gas**

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### **Abstract**

Cavity ring-down spectroscopy (CRDS) also known as Cavity ring-down laser absorption spectroscopy is a laser absorption technique used for quantitative determination of atomic and molecular species with a high sensitivity compared to other techniques. Light from a tuneable semiconductor diode is directed into a small high finesse optical cavity with high reflectivity mirrors (>99.995%) containing the analyte gas, which circulate in the cavity  $\approx 10^7$  times, travelling about 20 km or more. The precession of CRDS comes from this incredibly long path length providing part-per-billion (ppb) detection levels for some gases. The energy decays from the cavity as a result of loss mechanism is recorded as a function of time ( $\tau$ ). The unique advantage of using CRDS is that  $\tau$  is independent of the initial laser intensity and hence offer unmatched measurement precision. In this paper we have used high accuracy CRDS (Tiger Optics) techniques for the measurement of impurities of CH<sub>4</sub> and H<sub>2</sub>O in purity nitrogen. The lowest detection limit of CRDS used is 2 ppb and 200 ppt for CH<sub>4</sub> and H<sub>2</sub>O respectively, whereas the detection range of the CRDS is 0 - 8 ppm and 0 - 5 ppm for CH<sub>4</sub> and H<sub>2</sub>O, respectively. Analysis of impurities was done in controlled environmental condition. The concentration of CH<sub>4</sub> and H<sub>2</sub>O in nitrogen is found to be in the range of  $274 \pm 72$  ppb and  $884 \pm 14$  ppb, respectively.

**Keywords:** CRDS technique, Impurity analysis, CH<sub>4</sub> and H<sub>2</sub>O, Purity nitrogen gas

## Multipoint Calibration Versus Bracketing Method in Determination of Carbon Monoxide in Nitrogen by Gas Chromatograph Technique

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### Abstract

The choice of calibration methodology to obtain the calibration function is crucial to calculate the accurate amounts of an analyte as a function of an instrumental signal. It is well known that the analysis of any analyte using any analytical techniques like Inductively Coupled Plasma, Atomic Absorption Spectrometer, Gas Chromatograph etc need calibration of equipments using calibration standards. Calibration by linear regression analysis requires minimum three standards and uncertainty associated with this is also higher. A two point method of calibration (bracketing) is proposed for the calibration which reduces the uncertainty and also improves measurement. This method has the advantage of approximately compensating for non-linearity in the analytical curve, if the two standards are close in concentration to the sample. In this paper, multipoint calibration and bracketing method were applied to an in-house optimized GC-Flame Ionization Detector technique for CO analysis. The calibration curve for multipoint calibration was obtained by regression analysis using three gas mixtures prepared gravimetrically as per ISO 6142 (at NPLI) in the range 87 - 113  $\mu\text{mol/mol}$  CO in nitrogen that covers the range of concentrations expected in sample gas mixture of CO in Nitrogen. In bracketing method of calibration, two standards are taken - one with a lower concentration (87  $\mu\text{mol/mol}$ ) than the unknown and the other with a higher concentration (113  $\mu\text{mol/mol}$ ). The calibration curve segment between the two standards can be considered linear and an accurate determination can be realized applying the linear equation for two points. The signal intensities of standards and the sample in bracketing method is measured in such a sequence one after other that it compensates the drift of detector response, if any, during the run. A gravimetrically prepared control sample is also used for quality control of the analytical method in sequence. The amount of CO in unknown sample is calculated with the expanded uncertainty (at  $k=2$ ) in a different way in each of these calibration methods and is found  $101.71 \pm 4.22$   $\mu\text{mol/mol}$  and  $100.61 \pm 0.83$   $\mu\text{mol/mol}$  for multipoint and bracketing method respectively. The uncertainty of the CO in nitrogen gas mixture is found to reduce from 4% in multipoint calibration method to less than 1% in the bracketing method.

**Keywords:** GC-Flame Ionization Detector, Multipoint calibration, Bracketing method

## Experimental Study on Singularity and Wave-front Tearing in Monochromatic Dark Hollow Beam

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### Abstract

Hollow optical beams have been subjected to extensive studies because of their ease and efficient generation and their potential applications in many areas including non invasive optical manipulation, micromachining, atom confinement and medical applications. Recently, generic singularity and induced wave front tearing have been illustrated in polychromatic dark hollow beam for the first time. In the present investigation, we have demonstrated singularity and tearing in monochromatic dark hollow beam generated from a He-Ne laser (633nm) using an axicon Ax and lens L assembly having f# 4.7, as depicted in Fig.1. A is pinhole of size 0.1mm, introduced to rebuild the spatial coherence after diffuser D. In addition, the effect of change in position (in the direction of propagation of beam), modification in coherence by rotating diffuser D and the lateral shifts in axicon (perpendicular to the propagation direction of beam) have been studied. We observed that both polychromatic and monochromatic hollow beams generate singularity and induce wave front tearing which remains unaffected by the speed of rotation of diffuser but enlargement in wave front tearing with lateral shifts in axicon is detected. A shift of 3mm in axicon results in a growth of wave front tearing in dark hollow beam is observed as shown in figure 2. Figure 3 clearly shows the generation of singularity and wave front tearing in monochromatic dark hollow beam.

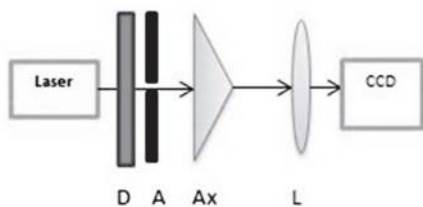


Fig: 1

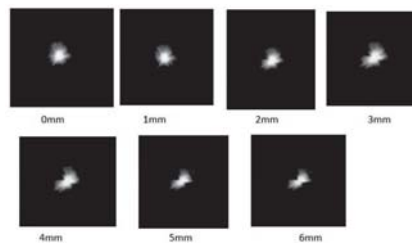


Fig: 2

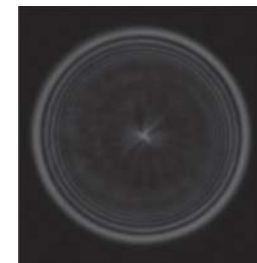


Fig: 3

**Keywords:** Polychromatic dark hollow beam, Monochromatic dark hollow beam, Optical singularity.

## Comparative Study of Natural Frequency on an L Structure with Crack and End Mass Induced

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### Abstract

In this article the natural frequency is compared with the analytical and FEM method on an L-structure by inducing the Crack and End mass and the behavior of the structure is studied. The L-structure material is taken as Aluminium with dimension 30x50 mm cross section with length 900 and 600 mm. The crack location is varied at 4 different locations in each length of structure with crack size variations at 6 different progressive levels along with the end mass variations of 0.4, 0.6 and 0.8 Kg which is applied on the L-structure. The L-structure which is in inverted position forms 2 segments which has cantilever effect on one side but has strong vertical segment base. The results obtained when crack is induced along with End mass are equated with no crack and no End mass condition in both Analytical Euler-Bernoulli method and FEM method, later the comparison is made with the Analytical method results to the FEM results generated using ANSYS software. In this comparison study, variations which are absorbed between the results obtained are discussed. Certain points of observed results which are affected are discussed with explanations.

**Keywords:** Natural frequency, crack size, crack depth, end mass, modal analysis.

## Uncertainty Estimation of Metal Determination in Aerosols Listed in NAAQS

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### Abstract

Determination of metal/metalloids in particulate matter (PM) samples is an important task. Toxic effects of some metals have been observed worldwide leading to formulation of guidance for monitoring and regulating their concentrations in the aerosols. Here, we are presenting the uncertainty involved in the determination of metals (e.g. As, Ni and Pb) which are criteria pollutants listed in national ambient air quality standards (NAAQS). The regulatory limits of As, Ni and Pb given in most of the NAAQS of different countries are very low, e.g., in NAAQS - India it is regulated to be 6, 20 and 500 ng/m<sup>3</sup>, respectively. Therefore to assess the air quality in context of these metal pollutions, precise and accurate measurement is very important. The reference analytical techniques for metal determination are atomic absorption spectrometry (AAS) and inductively coupled plasma (ICP) spectrometry. ICP- high resolution mass spectrometry (HRMS) is a very sensitive technique and can detect trace elements at very low concentration in a given matrix with comparatively lower uncertainty. Analysis of As using ICP-HRMS also does not require hydride generation as it is needed in AAS, which may add further to the measurement uncertainty. Here we present the uncertainty involved in the determination of As, Ni and Pb using ICP-HRMS. The objective of this work is to evaluate whether low concentration of metals in PM matrix can be determined precisely using ICP-HRMS. Ambient aerosol particles collected on quartz filters were acid digested and analyzed in triplicates. Average concentrations of As, Ni and Pb in spring samples in New Delhi are determined to be 3.53±0.95 (range: 2.76–5.78), 11.75±3.48 (range: 7.70–16.49) and 204.9±102.3 (range: 80.1 – 359.4) ng/m<sup>3</sup>, respectively. Expanded uncertainties (at  $k = 2$ ) associated with As, Ni and Pb determination varies between 15 – 22%, 12 – 15% and 12 – 15%, respectively. This study suggests that major uncertainty components in metal measurements are related to sample digestion followed by instrumental determination and filter sampling.

**Keywords:** As, Ni and Pb measurement with uncertainty, NAAQS metal measurement, ICP-HRMS

## Variation in Particle Size Standards within and after Shelf-life Measured using Differential Mobility Analyzer

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### Abstract

In aerosol research, differential mobility analyzer (DMA) is widely used for particle size distribution measurements. In general polystyrene latex (PSL) particle size standards are used to calibrate the DMAs. However, these standards are expensive, and their shelf-life is limited. Therefore in this work, we have used PSL particle standard of sizes 60 and 100 nm (SRM® 1964 and SRM® 1963a, respectively) and checked their performance within and after the shelf-life period for 3 consecutive years (2013 – 2015) using a calibrated DMA (i.e., long-DMA, TSI 3081). Also the size results are compared using a reference DMA (i.e., nano-DMA, TSI 3085). Using both long- and nano-DMA, the detail results of standard particle size measurements and involved uncertainties are discussed in this paper. We observed a continuous increase in the count mean diameter (CMD) calculated from the size distribution of each standard particle size with the progress of time. Particle size measured for PSL 60 and 100 nm using long-DMA are (56.01±5.05) nm and (92.86±7.11) nm in 2013, (56.37±5.01) nm and (93.71±7.09) nm in 2014, and (57.42±5.00) nm and (94.79±7.38) nm in 2015, respectively. Whereas, these results when nano-DMA was used are (56.82±5.07) nm and (94.62±7.27) nm in 2014, and (58.08±4.47) nm and (95.15±7.29) nm in 2015, respectively. Uncertainty results show that the components which contribute significantly in total uncertainty (at  $k=2$ ) in CMD measurements are DMA transfer function, DMA calibration, CPC counting precision, and DMA inner-electrode voltage. The size measurement results obtained from long-DMA and nano-DMA are agreed well. Based on the measurement results, we suggest that the increasing trend of particle sizes (CMDs) with the progress of time from 2013 to 2015 is possibly because of the coating of contaminant residues (present in the standard liquid suspension) on the surface of the PSL particles which is further observed by high resolution tunneling electron microscope (HRTEM) images of particles. Particle standards are stable and well characterized more than two years even after their self-life within the uncertainty limits. Size performance results for PSL 60 nm using calibrated long- and reference nano-DMA show good agreement with the size value given in the certificate, however standard PSL 100 nm size is found to be underestimated by ~7%.

**Keywords:** Performance check of PSL standards, DMA size measurement, Uncertainty calculation

## Resistively Heated Atomic Oven for Single Ion Trap Experiment

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### Abstract

In CSIR-National Physical Laboratory, work in progress about developing one of the most accurate frequency standards based on an ultra-narrow hyperfine transition of a single trapped ytterbium ion. A single  $^{171}\text{Yb}^+$  ion will be confined and laser cooled within a specially designed radio frequency ion trap, where the tip to tip separation between the two electrodes of the trap is less than 1 mm. The ytterbium ions are produced by photo-ionization of ytterbium atoms and the neutral ytterbium atoms are produced by an effusive atomic oven. Low divergent atomic beam focused at the trap centre is an essential requirement for stable trapping of single ion as any deposition of ytterbium atoms on the electrodes may create a patch potential and leads to an unstable trapping of ion. We have designed and constructed an effusive atomic oven for the production of low divergent and controlled atomic beam. The oven has two major components, the first part made of stainless steels (SS) having a needle of inner diameter of ~ 0.5 mm for the emission of atomic beam and the needle is attached to a larger volume SS chamber filled with metallic ytterbium. The second part is a ceramic cavity where the SS chamber is push fitted. A nichrome heating coil is wound around the ceramic cavity for heating the ceramic cavity and eventually heating the atomic oven and results into emission of atomic beam through the SS needle. The temperature of the oven can be controlled by changing the current of the heating coil and flux of the atomic beam can also be controlled. When the atomic beams are coming out of the oven they are collected on a glass plate placed directly in front of the needle. The divergence of the atomic beam is measured by measuring the diameter of the atomic beam at different distance from the emission needle. The dependence of atomic beam divergence on the oven parameters like length and diameter of the needle have also been studied. A new method has been developed for quantifying the atomic flux and its dependence on the oven temperature.

**Keywords:** Atomic oven, Single ion trap, Atomic beam



## Spectroscopic Investigations on the Adductation of Anticancer Drug Mitoxantrone with tRNA

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### Abstract

Mitoxantrone (1,4-dihydroxy-5,8-bis [[2-[(2-hydroxy ethyl) amino] ethyl] amino]-9,10-anthracenedione) is a rationally designed antineoplastic agent. It is widely used as a potent chemotherapeutic component in the treatment of various kinds of cancer. Widespread significance for anticancer agent mitoxantrone has emerged due to its apparent lower risk of cardio-toxic effects with respect to naturally occurring anthracyclines. In the present study, we have investigated the binding attributes of mitoxantrone-tRNA complexation at physiological pH using attenuated total reflection- Fourier transform infrared (ATR-FTIR) spectroscopy, circular dichroism (CD) spectroscopy and UV-Visible absorption spectroscopic techniques. FTIR analysis revealed the interaction of mitoxantrone with heterocyclic nitrogen base residues of tRNA along with fine external binding with phosphate-sugar backbone. In particular, mitoxantrone binds on uracil (C=O) and adenine (C=N) sites on base residues of biomolecule. Circular dichroism spectroscopic results suggest that there is no major conformational transition in native A-form of tRNA upon mitoxantrone-tRNA adductation except the intensification in biomolecular secondary structure. The binding constant calculated for mitoxantrone-tRNA association was found to be  $3.07 \times 10^3 \text{ M}^{-1}$  indicating moderate affinity of drug with tRNA. Investigation of drug-tRNA interaction is an essential part of rational development of RNA targeting chemotherapeutic agents that also delineates structural-functional relations between drug and its target at molecular level.

**Keywords:** Mitoxantrone, tRNA-drug interaction, FTIR spectroscopy, CD spectroscopy

## Hybrid Nano-Biomaterials: an Endeavor to Curtail Constraints in Nonlinear Applications

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### Abstract

Efficient manipulation of photonic signals is extremely important for progress in technologies such as optical communication and computing, dynamic image processing, optical processors, optical switches, wavelength filters and modulators. Thus, extensive research efforts have been directed toward nonlinear optical (NLO) properties of materials. Among a wide range of NLO molecules, biomaterials have gained special interest for many investigators due to their remarkable properties which cannot be easily replicated with conventional organic or inorganic materials in the laboratory. Furthermore, natural biomaterials are a renewable resource and are inherently biodegradable. Thus Nano Bio-Photonics has emerged as a promising area of research which exhibits tremendous increase in its constituent performance and functional opportunities. In order to attain an increased photon–photon interaction and consequently, the NLO response with a greater tuneability, this paper presents state-of-the-art fabrication and characterization of advanced hybrid Nano-Bio systems composed of a biomolecule exhibiting wavelength dependent field enhancement, nonlinear refractive index and optically switchable features for their potential applications in bio inspired engineering systems. We studied oligonucleotide as well as polypeptide functionalized nanoparticle assemblies. While the research confirmed generation of high local-field enhancement when excited at their plasmon resonance.

**Keywords:** Nonlinear Optical Properties, Nano Bio-Photonics, Optical Switching, local-field enhancement

## Probing Nucleic Acid (tRNA) Interaction with Anti-cancer Alkaloid

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### Abstract

Flavopiridol, a semi-synthetic derivative of rohitukine, has attained much attention owing to its anticancer potential against various hematological malignancies and solid tumors *in vitro* and *in vivo*. This work focuses towards understanding the interaction mechanism of flavopiridol with tRNA at molecular level. Various spectroscopic techniques such as attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy, circular dichroism (CD) and absorption spectroscopy have been utilized to define direct influence of flavopiridol on the structural and conformational aspects of RNA. Vibrational spectroscopic techniques were employed to characterize the binding of flavopiridol with tRNA. CD spectroscopy provided information on conformational transitions in tRNA associated with its complexation with flavopiridol. The other binding parameters such as binding mode, strength and stability were determined using UV-visible spectroscopy. The outcomes of this investigation will provide comprehensive understanding on the interaction of flavopiridol with nucleic acid and reinforces the capability of spectroscopic methods in deciphering the action mechanism of small nucleic acid binding molecules. It can further helpful in probing the cytotoxicity induced by flavopiridol and in rational designing of more RNA targeted chemotherapeutic agents.

**Keywords:** Flavopiridol; Drug-tRNA interaction; CD spectroscopy; ATR-FTIR spectroscopy

## A Novel Methodology for Simulations in Metrology using Axioms

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### Abstract

Axiomatization is a process of setting mathematical rules from linguistic understanding of real world processes and phenomenon. Axiomatic basis is constituted by assertions, logical operations and the resultant theorems. Simulations are derived from the axiomatic basis. Simulations have qualitative matrices of summarized assertions, assumptions and boundary conditions. A given problem e.g. external cylindrical diameter measurement can be measured using coordinate measurement, floating carriage methods. The uncertainty of measurement of these methods is 170 nm at NPL-India. Diameter measurement is simulated for these two different methods. Unfortunately, the qualitative matrices of these simulations cannot be mathematically operated. Gödel's theorem states that no physical system can be simulated both complete - consistent.

A novel methodology is devised to quantize the axiomatic basis of simulations in metrology. This method also circumvents the Gödel's inconsistency - incompleteness impasse of simulations through three tier recursive querying. In the proposed method, the constituents of simulations are examined for 1) consistency 2) completeness 3) context sequentially. During three stages, the simulations are recursive queried to quantize the axioms in to matrices. Thus, the mathematically operative matrices of simulations are derived.

The two simulations are compared using their respective matrices. An optimized diameter measurement method is simulated with an inference of the above simulations. The simulation is realized to achieve an improved uncertainty of measurement of the order of 90 nm.

**Keyword:** Metrology, axiom, simulations, uncertainty of measurement, calibration.

## Calibration of Dial Testers using Laser Interferometer at CSIR-NPL, India

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### Abstract

Dial gauges are extensively used in engineering industry to measure displacement. Digital dial gauge are popular for their digital display and improved resolution below 0.5  $\mu\text{m}$ . dial gauges are calibrated using dial testers. Commercially, various versions of dial testers are available up to 100 mm measuring range. The least count of dial testers ranges from 0.01  $\mu\text{m}$  (electronic read out) to 0.2  $\mu\text{m}$  (mechanical read out). Dial testers may be categorized as mechanical version, electronic version, with rotating or non-rotating spindle.

Conventionally, dial tester calibration is carried out using electronic LVDT probe in conjunction with reference gauge blocks. Different sizes of gauge blocks are wrung between anvils of LDVT probe - dial tester to determine the error at each graduation of dial tester. In this laborious process gauge blocks deteriorates. Because of continuous human intervention, the repeatability in this method is limits to 0.2  $\mu\text{m}$  or sometimes even worse. The uncertainty of measurement will be approximately  $0.3 \mu\text{m} + 1.1 \times 10^{-6} \times L$  m. Here L represents the value of graduation of dial tester in metre.

At NPL-India, a new calibration method is devised using displacement laser interferometer (LI) for different types of dial testers. The retro-reflector of LI is directly mounted on the non-rotating spindle of dial tester to perform the calibration. In case of rotating spindle, the interferometer will be misaligned when spindle rotates and LI will cease to work. A plunger mechanism of 50 mm long stock is fabricated using an abandoned precision dial gauge. This mechanism is mounted on dial tester above its anvil. The plunger transfers only translation movement of anvil of dial tester. Different dial testers are calibrated by either of this arrangement. The systematic error due to misalignment of laser is determined using gauge blocks, LVDT probe and this error is compensated. Various error components involved in these calibrations are identified to estimate uncertainty budget. An improved uncertainty of measurement  $0.12 \mu\text{m} + 0.6 \times 10^{-6} \times L$  m is achieved.

**Keywords:** Dial Tester, Laser interferometer, Rotating spindle, Uncertainty measurement.

## Study of Effect of Eccentricity and Pyramidal Error of the Polygon Calibration

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### Abstract

In order to realize the high precision measurement of encoder accuracy, the principle and method to measure encoder accuracy by using polyhedron and autocollimator are introduced. The polyhedron coordinate system and autocollimator measurement coordinate system are established, and the precise mathematical model is established, which is relation with the measurement error of the encoder accuracy and pyramidal error. The simulation results show that the encoder shaft tilt angle and tilt direction will affect the measurement results of the encoder accuracy. Measurement error of encoder accuracy increases with encoder shaft tilt angle, and approximately proportional to the square. Measurement error of encoder accuracy changes with encoder shaft tilt direction. When encoder shaft tilt direction is  $0^\circ$  or  $180^\circ$ , measurement error is the smallest; When encoder shaft tilt direction is  $90^\circ$  or  $270^\circ$ , measurement error is the maximum. As encoder shaft tilt angle is  $5^\circ$ , the measurement errors can reach  $0.11\% \sim 0.48\%$ , which cannot be ignored for encoder with 1~3 levels of precision grade. Pyramidal error should be controlled in the appropriate range based on the precision grade of measured encoder. Specific requirements on pyramidal error are given for encoders with different precision grades. ©, 2015, Chinese Optical Society. All right reserved

**Keywords:** Dial Tester, Laser interferometer, Rotating spindle, Uncertainty measurement.

## A New Twin Post Pressure Balance Type Hydraulic Differential Pressure Standard

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### Abstract

The differential pressure ( $p$ ) is measured either between two points on independent systems or between two different points on the same system. One of the main uses of differential pressure sensor is to measure the difference in fluid or gas pressure across a restriction in a pipe. It is a known fact that the accuracy of the differential pressure transducers / transmitters is greatly dependent on static or line pressure. Still most of the laboratories perform calibration keeping one port of the differential pressure transducers / transmitters to an atmospheric pressure. One of the main reasons for this is that the calibration at high static pressures is very expensive and complex operations. In order to address this problem, a new twin post pressure balance type hydraulic differential pressure standard is established for the calibration of differential pressure gauges and pressure transducers / transmitters. The system is capable to provide traceable calibration service to users and industries in the differential pressure range (0 - 50) MPa at high line / static pressure from (0.2 - 50) MPa having measurement uncertainty better than 100 ppm. This paper also describes the studies carried out on a differential pressure transducer in the differential pressure range (0 - 2) MPa at static pressure of (0, 0.2, 10, 20, 30, 40 and 50) MPa. It is clearly observed from the studies that calibration factor shifts with increase in static pressure. It is also observed that the zero pressure value of the device under test reduces with increase in static pressure.

**Keywords:** Uncertainty, differential pressure, static pressure, twin post pressure balance

## Effect of Burden on Current Transformer

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### Abstract

The current transformer (CT) is a widely used instrument transformer in a bulk energy measurement system. The CTs are designed for specified burden at the required accuracy. The CTs selection has to be carefully made depending on its application. Thus an appropriate burden depending upon the requirement should be chosen before customizing the CT.

In this paper, we report the effect of burden ranging from leads burden to 10 VA on a 500A/1A CT. The measurements were carried out on 500A/1A CT for various burdens against the Current Comparator (Standard) having 500A/1A ratio with an accuracy of  $\pm 30$  ppm. The measurements were carried out at 100% excitation current on the CTs in controlled environmental condition of temperature:  $(25 \pm 2)^\circ\text{C}$  and relative humidity:  $(50 \pm 10) \%$ . During the measurement, a current of 500A was supplied from a high current source to both the CTs in series as shown in fig.1. The ratio error and phase angle error were measured by comparison method using an Automatic Instrument Transformer Test Set (AITTS). The measurements were carried out using various burdens and the results are shown in fig.2.

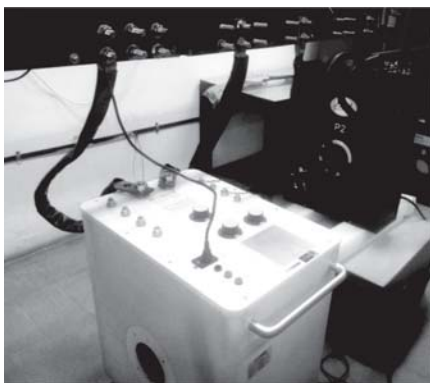


Fig.1 Current transformers set-up for measurement

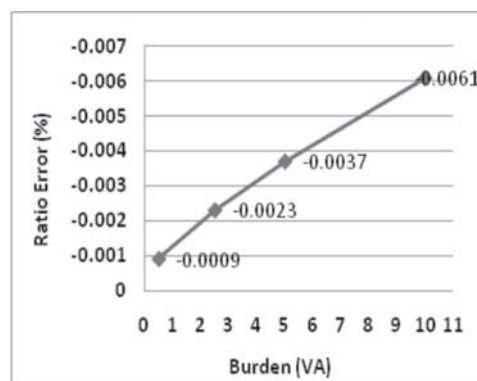


Fig. 2 Change in ratio error of current transformer at various burdens

It is observed that the ratio error increases with the increase in burden. There is substantial increase in the ratio error from leads burden to 10 VA burden. The factors affecting the ratio error with various burdens will be presented in detail.

**Keywords:** Current Transformer, Burden, Ratio Error, AITTS



## **Measurement of the Gravity Induced Distortions on the Satellite Reflectors during CATF testing**

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### **Abstract**

During the CATF testing of a satellite, the reflectors are deployed using simulated zero g setup. To simulate the in orbit conditions, gravity forces acting on the reflector have to be compensated. This is done usually by giving 0-g backup support for carrying out antenna characterisation. During these tests, the antenna along with S/c is rotated about the mounting axis in elevation for various scan angles. During this elevated antenna condition, there is a possibility that the reflector may get deformed due to components of gravity forces acting on the reflector and the backup support. This is quantified by taking CRP measurements of the antenna w r t SCCS for various scan angles. The relative distortion (angular) between the back up support and the reflectors can be derived using transformation equations. These bias/angular distortions are adjusted from the reflector pointing/coverage plots after the patterns measurements. This paper includes the methodology of the measurement process, the challenges faced during measurements and the results for a typical spacecraft.

**Keywords:** CATF, CRP, SCCS, Gravity Induced Distortion

## Importance of Temperature Suitability Test in Calibration of Domestic Water Flow Meters

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### Abstract

The CSIR – National Physical Laboratory India New Delhi is the premier research and development organization in India to maintain upgrade and disseminate the units of measurements like mass, temperature, time current etc. CSIR – National Physical Laboratory has also Fluid Flow Measurement facility to realize, upgrade and disseminate the units of Flow Measurement.

While calibrating flow meters, the water temperature variation within the temperature range specified must not adversely affect the material used in the construction of the water meter it should not affect the potability of water. When the laboratory carrying out calibration at National level, it is necessary that the temperature of the liquid (water) does not change more than 1p C in one hour as the temperature variation at new Delhi are quite high and touches extreme both in summer as well as in winter for carrying out the temperature suitability test the meter under test are immersed in water bath having constant temperature  $45\text{p C} \pm 1\text{p C}$  for 10 hours and is then kept out and kept for some time in the open to acclimatize it at the ambient temperature. The meter is then again going for the accuracy test, if it is deemed to satisfy the performance after the temperature suitability test satisfies the requirements, the test equipment consists of a constant temperature water bath of about 25 Lts. Capacity housed in an insulated box is equipped with an electrical heater of 1.5 kw controlled by a microprocessor based temperature controller to maintain constant temperature of water within  $\pm 1\text{p C}$ , the bath has enough space to accommodate more than 10 meters at a time (size 15 mm, 20mm, 25 mm) and 2 meters of (sizes 40 mm & 50 mm dia) at a time for testing.

**Keywords:** Water Flow meter, Calibration, Flow measurement

## Study of Oxaliplatin Interaction with ctDNA Duplex by using Spectroscopic Techniques

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### Abstract

Oxaliplatin is the first platinum-based anticancer drug to be approved for the treatment of colorectal cancer, a major cause of cancer deaths worldwide. It is an alkylating agent, which contains platinum complexed to oxalate and diaminocyclohexane (DACH). Like other platinum compounds, oxaliplatin inhibits DNA replication and transcription through the formation of intra- and interstrand DNA adducts. In the present study, the binding properties of oxaliplatin with calf thymus DNA (ctDNA) was investigated using FTIR spectroscopy, circular dichroism and ultraviolet visible (UV-vis) spectroscopy. FTIR spectroscopy serves as an effective method for analyzing molecular structure as well as their confirmation. Binding sites and sequence specificity can also be determined by using this technique. Circular dichroism (CD) spectroscopy is a valuable technique to explore non-covalent drug-DNA interactions where subtle conformational changes due to complex formation between the ctDNA and oxaliplatin can also be observed. While ultraviolet visible (UV-vis) spectroscopy can provide the binding strength of the interaction. The results obtained from the study are encouraging and suggests base binding of oxaliplatin with DNA. The proposed analysis of DNA-drug interaction studies can provide the better understanding of binding mechanism which can be applied in the process of rational drug development, possessing better efficacy and potential binding with biomolecules.

**Keywords:** Oxaliplatin, DNA-drug interaction, FTIR spectroscopy, UV-vis spectroscopy, Circular Dichroism

## **Effect of Pressure on the Two Plates of Ultrasonic Sandwich Transducer for Ultrasonic Cleaning and NDT Applications**

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### **Abstract**

Sandwich type of ultrasonic transducers is used in ultrasonic high power applications like ultrasonic cleaning, levitation, emulsifiers and ultrasonic NDT. In this sandwich type transducer piezoelectric element are sandwiched by tightening the bolts through multiple rings or disc of ceramics. Present work reports results on measurement of impedance and conductance of PZT element at varying frequency at different pressures. Work will help to ensure and to determine nominal pressure at which these transducers offer maximum electro-acoustic efficiency, low heat generation and provide maximum amplitude at desired working frequency. A piezoelectric ceramic PZT-5 disc in ring shape with thickness 6 mm, inner diameter 9 mm and outer diameter of 23 mm is taken for measurements. PZT Ring is sandwiched by two metal washer and acoustic absorbers near to element through nut bolt. Pressure is varied by providing different torque on bolt. Impedance and conductance measurements for various frequencies in range 5 to 400 KHz at different pressures is made using the Wayne Kerr- 6540A Precision Impedance Analyzer (1 KHz -120 MHz). Fundamental and harmonic frequencies are clearly observed at various pressures. At higher pressures the efficiency reduced and amplitude becomes negligible. Results will be helpful in designing the high power ultrasonic transducers for ultrasonic cleaning and NDT applications.

**Keywords:** Ultrasonic transducer, Sandwich transducer, Ultrasonic cleaner, NDT

## Optical Setup for Laser cooling, Launching and Detection of Cesium Atoms

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### Abstract

Narrow linewidth lasers are routinely used for cooling, manipulation and detection of atoms [1]. We use a narrow linewidth laser whose frequency is 351 THz to perform saturated absorption spectroscopy and resolve peaks separated by few MHz. The cavity length and diode current of the laser can be locked to get the desired laser frequency. The laser locking is implemented in the laboratory to a frequency corresponding to the hyperfine transition in a cesium atom. The laser frequency can be changed and controlled by an acousto-optic modulator within few tens of MHz. The ultra-fast frequency control allows polarisation gradient cooling of atoms, launching of atoms and also to drive light frequency out of atomic resonance to reduce light shift of energy levels. We have implemented such an optical setup for Cesium Fountain Frequency Standard, India Cs-F1 [2]. For Cs-F2, an Interference filter-stabilized external cavity based diode laser is being implemented for atom manipulation and control. The laser consists of very narrowband, low loss interference filter instead of diffraction grating for wavelength selection, and an output coupler to generate the feedback. The optical set of Cs-F2 will be presented and compared with that of India Cs-F1. The design of home-made beam expander producing laser beam for atom control and detection will also be presented.

[1] Frequency and Intensity Control of Lasers to Cool and Control Caesium Atoms, Ashish Agarwal and A. Sen Gupta, MAPAN-Journal of Metrology Society of India; 27 (2012) p169, DOI:10.1007/s12647-012-0026-9

[2] Development of cesium fountain frequency standard at the National Physical Laboratory, India; A. Sengupta, Ashish Agarwal, P. Arora and K. Pant, Current Science **100** (2011) 1393.

**Keywords:** Atom manipulation; Cooling and trapping of atoms; Frequency standards; Diode lasers

## Establishment and Verification of a New PVTt Primary Low Pressure Gas Flow Standard

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### Abstract

A new pressure, volume, temperature, and time (PVTt) low pressure gas flow standard (see Fig. 1) has been established in Center for Measurement Standards (CMS). The PVTt facility works in the flowrate range of 0.01 L/min to 300 L/min using three gas collection tanks with an expanded uncertainty ( $k = 2$ ) of 0.10 %. Each collection tank is equipped with an individual three-way diverter valve composed of a specially-designed reduced-bore ball valve and a pneumatic cylinder. To maximize the accuracy of gas temperature measurement, the collection tanks are immersed in a circulated, temperature stabilized water bath. As a result, the uncertainty of the collected gas temperature measurement after achieving thermal equilibrium is 0.05 K. The design of this flow standard and the strategy to reduce the flow measurement uncertainty will be introduced in this talk. In addition, to verify the capability of the new facility, an intra-comparison between the PVTt gas flow standard and three other existing primary gas flow standards at CMS, i.e. a mercury-sealed piston prover and two bell provers, and an inter-comparison with the PVTt gas flow standard at the National Institute of Standards and Technology (NIST) of the United States were conducted. Intra-comparison results show that the deviations between the PVTt facility and the other three systems are within 0.05 %, and that the CMS and NIST's PVTt facilities agree well with each other. The experience learnt during the process will also be shared in this talk.

**Keywords:** Gas flow measurement, Uncertainty, Water bath, Intra-comparison, Inter-comparison

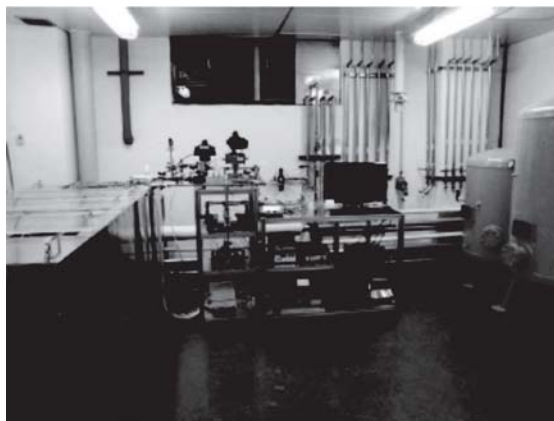


Figure 1. The PVTt low pressure gas flow facility established at CMS

## **Functionalized Cobalt Ferrite Nanoparticles for Removal of Pathogenic Bacteria: A Potential Material for Diagnostic Applications**

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### **Abstract**

The present investigation deals with the synthesis and characterization of functionalized cobalt ferrite nanoparticles for removal of pathogenic bacteria. The synthesized material reveals high superparamagnetic property and size ranging in ~5-6 nm. The functionalized MNPs are used without the need of any further modifications with affinity biomolecules. The high surface area of functionalized cobalt ferrite nanoparticles provides a promising and sophisticated platform for detection of bacteria. The amine groups present on the surface functionalized cobalt ferrite nanoparticles are robust and inexpensive ligands to ensure a high binding affinity for Gram-positive and Gram-negative bacteria. The functionalized cobalt ferrite nanoparticles allow rapid removal of bacteria from water samples with high efficiency. These functionalized MNPs are attractive avenues for capturing a wide range of bacteria and will play a vital role in diagnostic applications.

**Keywords:** Ferrite nanoparticles, Bacteria, Diagnostic applications

## Uncertainty Analysis of Developed ANN and ANFIS Models in Prediction of Daily Atmospheric Boundary Layer Height

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### Abstract

This study aims to predict daily atmospheric boundary layer (ABL) height in the atmosphere of Delhi by means of developed artificial neural network (ANN) and adaptive neuro-fuzzy inference system (ANFIS) models. Forward selection (FS) and Gamma test (GT) methods are used for selecting input variables and developing hybrid models with ANN and ANFIS. From 9 input candidates are selected using FS and GT respectively. Evaluation of developed hybrid models and its comparison with ANN and ANFIS models fed with all input variables shows that both FS and GT techniques reduce not only the output error, but also computational cost due to less inputs. Finally, uncertainty analysis is carried out for FS-ANN and FS-ANFIS models.

**Keywords:** Forecasting, Mixing Height, Artificial Neural Network (ANN), Adaptive Neuro-Fuzzy Inference System (ANFIS)



## Development of Blackbody Calibrator for IR Clinical Thermometers

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### Abstract

The measurement of body temperature is a basic parameter and vital sign of the human body health. Over the last few years there are several new clinical thermometers coming up in the market based on electrical and infra red (IR) type sensors to avoid the mercury toxicity. The world health organization (WHO) and Minamata convention has a mission to phase out mercury in the health care by year 2020. The non-contact type IR Ear and forehead thermometers are advantageous over the contact type thermometers because of their use in contagious situations such as SARS, H1N1, Ebola, chikungunya, etc. For clinical IR thermometers, the maximum permissible error of  $\pm 0.2$  °C is allowable in the temperature range from 35 °C to 42 °C. In order to gain credibility and confidence in the usage of IR ear thermometers, a standard blackbody source (BBS) with a calibration traceable to ITS-90 is needed. Therefore, in the present investigation, the copper black body cavity has been designed and fabricated to get the emissivity of 0.99 and placed in a high stability water bath. The temperature of bath and hence IR cavity temperatures were measured by standard platinum resistance thermometer (SPRT) calibrated on ITS-90 fixed points. Various experimental parameters such as bath stability, emissivity variation and size-of-source effect are measured and optimized. The measurement performed with standard pyrometer and commercially available IR Ear thermometer in the range from 35 °C to 42 °C is shown in fig. 1, where the measurements are within  $\pm 0.2$  °C. The detail experimental results with uncertainty analysis for IR ear thermometer measured on our blackbody will be presented in this paper.

**Keywords:** Blackbody calibrator, Thermometer, Toxicity

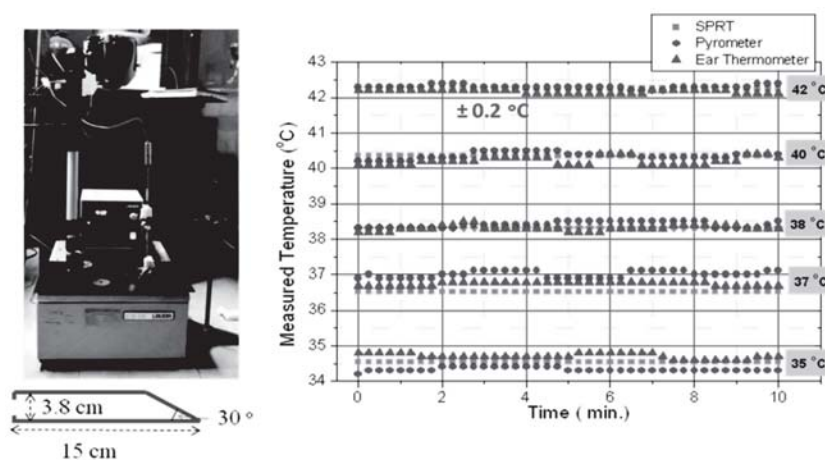


Fig. 1 : Experimental Set-up of copper black body cavity designed and fabricated at CSIR-NPL, and the measurements for IR Ear thermometer

## Evaluation of Technical Equivalence of Indian and International Coal Testing Methods through ILC based PT Study

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### Abstract

National Council for Cement and Building Materials (NCB) has implemented Interlaboratory comparison (ILC) based Proficiency Testing (PT) study on coal with the participation of 34 laboratories, during July-September 2015. Under the scheme, two homogenized samples of coal were sent to the participating laboratories for analyzing Moisture, volatile matter, ash, sulphur and gross calorific value. Tests were required to be conducted on air-dry basis. The results of moisture were taken for indicative purpose only and not included in performance evaluation.

### Study Implementation and Outcomes

The participating laboratories were given the choice to conduct testing as per any of four methods: IS, ASTM, ISO, EN. Of the 34 laboratories participating in the study, 22 were having NABL accreditation and 6 were applicant laboratories. 18 laboratories belonged to thermal power sector. The laboratories carried out testing of coal samples by IS/ASTM/ISO method. For moisture testing, participants used ASTM D5142, ASTM D7582 and ASTM D3173 (all methods are for total moisture). For determining volatile matter, ASTM D3175 and ASTM D7582 were used. For determining ash content, ASTM D4239, ASTM D7582 and ASTM D3174 were used. For sulphur (total) determination, ASTM D3177 and ASTM D4239 were used. For gross calorific value determination, ASTM D5865 was used. In Indian standard, above test methods are given in IS 1350 (Part 1 to 5). Details of test method followed, in terms of number of laboratories (N) for each parameter, are presented in the following Table:

**Test Methods Followed for Analysis**

Parameter	N	Standard		
		IS	ASTM	ISO
Moisture	33	23	9	1
Volatile Matter	32	22	9	1
Ash	34	24	9	1
Sulphur	25	10	14	1
Gross Calorific Value	33	17	15	1

The test results reported by the laboratories were summarized (for central tendency and spread) by calculating Median and Normalized Inter-Quartile Range (NIQR). The test results, analyzed collectively - irrespective of the standard followed - showed almost a similar pattern and a close range. In the earlier PT scheme conducted by NCB, which also had almost equal - but different - number of participants, majority of the laboratories had used IS method for analyzing all parameters and a few ASTM method for sulphur and gross calorific value. In the current scheme, the spread of the data (measured by SD and NIQR) reduced in moisture, volatile matter, sulphur and gross calorific value, in comparison to the previous scheme. Slight increase in the spread in results of ash may be due to three ASTM methods, along with IS and ISO method being followed for analysis in the current scheme. However, there is an overall improvement in the measurement performance. All the standard methods were thus found technically equivalent and considered for combined analysis and comparison. Z-scores for between laboratories variation (reproducibility) and within laboratory variation (repeatability) were computed for evaluating laboratory performance.

## Challenges in Metrology of Density Functional Theory

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### Abstract

Density Functional Theory is one of the most crucial and recent theories that promise to relate quantum physics with astrophysics with practical applications in all the fields of life. So far, it has helped us to calculate the temperature of molten iron in Earth and its subsequent conditions, study the potential energy surface of transition metal complexes, inorganic spectroscopy, vibrational spectroscopy, and to understand a plethora of other molecular dynamics and energetic. However, a major loophole in this theory is the complicated and cumbersome solution of the density functional equations. These calculations require the usage of massive computers with multiple other highly expensive equipments for precision of calculation. This is also the reason for the very slow advancement of this highly useful theory. This paper shall endeavor to introduce these metrological problems faced while working on Density Functional Theory and shall also give a basic introduction to this theory.

**Keywords:** Quantum Standards and Metrology, Density Functional Theory, Challenges in Metrology

## Development and Realization of Fe-C Eutectic Fixed Point Cell

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### Abstract

Primary fixed points defined on the International Temperature Scale 1990 (ITS-90) play an important role in the field of temperature measurements. It is always desirable to get low uncertainty in the measurement. However, at high temperatures by both contact and non-contact thermometry, it is quite challenging. This calls for more number of fixed points with periodic temperature intervals. The recently invented metal carbon eutectic technology has greater potential to establish the fixed points from 1100 °C to as high as 2700 °C. In this direction of developing new metal carbon eutectic fixed points at NPLI, we have successfully developed Co-C (1324 °C) eutectic fixed point and participated in APMP inter comparison. Now, in this paper we report design, development and realization of new Fe-C (1153 °C) eutectic fixed point cell. The first step in the development of Fe-C eutectic fixed point is the preparation of cell, where 4.2 wt. % of carbon was added to Fe (5N purity) powder in a graphite crucible. The design and construction of Graphite crucible, cleaning, assembly head, Iron-carbon mixing, etc. has been performed in-house at NPLI. The experimental parameters such as furnace profile, melting/freezing plateaus and heat flux immersion have been measured by using standard Type-S thermocouple. Fig. 1 shows that the three runs of Fe-C melting are within 2.08 $\mu$ V, resulting in the measurement precision of  $\pm 0.04$  °C. The details of the experimental results along with the uncertainty analysis will be presented in this paper.

**Keywords:** ITS-90, metal-carbon eutectics, melting plateau, heat flux immersion

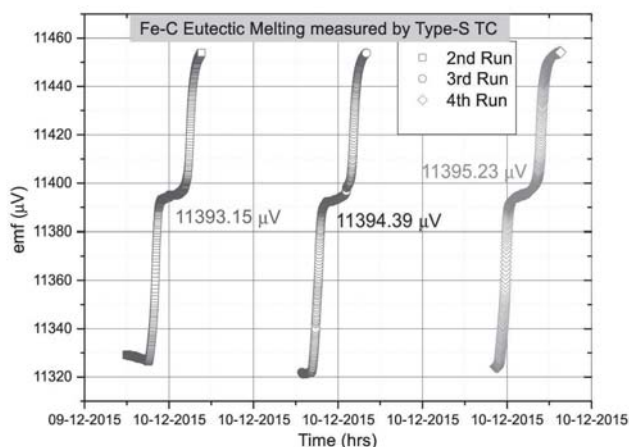


Fig. 1: Three runs of Fe-C eutectic melting profile of three runs measured by Type-S TC

## Muscle Force Measurement from sEMG Signals for Exoskeleton Devices

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### Abstract

Exoskeletons for human performance enhancement are wearable devices and machines that can increase the speed, strength and endurance of the operator. Many of the new proposed exoskeletons predicted the motion intent from EMG signals. The main advantage of EMG based exoskeletons is the ability to estimate the forces that will be generated by the muscles before the actual occurrence of mechanical contractions. This information is fed into the exoskeleton system such that by the time the physiological muscles contract the exoskeleton amplifies the joint moment by a preselected gain factor, resulting in a decrease in the reaction time of the human/machine system. In this paper the active force developed in the leg muscles is predicted from the EMG signals obtained from the four muscles of human lower limb while carrying out a task of standing to sitting. The predicted forces are then compared with inverse dynamic analysis of musculoskeletal model in AnyBody modelling system.

A subject of height 180 cm and weight 105 kg was made to perform trials of standing to sitting in squat position. sEMG signals from four muscles Vastus Medialis (VM), Vastus Intermedius (VIM), Rectus Femoris (RF) and Gluteus Medius (GMEDA) were recorded using BioTrace+ software and NeXus-10 biofeedback system at a sampling frequency of 2048Hz. The EMG signals were then exported to MATLAB for evaluation. The raw sEMG signals were processed to remove DC offset and low frequency noise. This was achieved by using a zero-lag fourth order recursive high pass Butterworth filter (30 Hz). The filtered EMG signal was rectified and normalized. Normalization is achieved by dividing the rectified EMG by the peak rectified EMG signal obtained for all the trials. The muscle activation signal is obtained from the processed EMG signal. Fig 1 shows the transformation of EMG to Muscle Activation Signal for VM. The Hill type muscle model was then used for estimating muscle force. The force predicted is compared with the force obtained from time musculoskeletal model performing similar task in AnyBody modeling system. Fig 2 shows the comparison of forces obtained.

**Keywords:** EMG, Exoskeleton, Inverse Dynamic Analysis, Muscle activation signal, Musculoskeletal model

## Road Distress Measurement Equipment

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### Abstract

Road distress data is an important input to the pavement management system. Manual measurement of road distress data is not only time consuming, it is also not practicable on road with high traffic densities. This paper describes Road Distress Measurement Equipment developed at CSIR-CRRI. The equipment is useful for expeditious and accurate measurement of road distress without disturbing the traffic. In the road condition evaluation survey system surface distress data is collected while moving on the road at normal traffic speed. The Road Distress Measurement Equipment consists essentially of two vehicle-mounted pavement view cameras capable of video graphing the road surface, with adequate sensitivity to pick up all required details and capable of being controlled and monitored from inside the moving vehicle. It also consists of two front asset view cameras. Distance travelled and speed of the vehicle is measured by DMI (Distance Measuring Instrument) fitted in the rear wheel of the vehicle. The video output of the pavement cameras is fed through a conventional video interface card to the PC. PC is also connected to receive a digital input from a distance measuring unit through micro controller and serial port adapter. Video and distance data is integrated and analysed in the PC. The Video Analysis System utilizes the output of the Video Survey System as its input, and gives as output the processed and analysed information on pavement surface condition of the road sections studied, in a format directly utilizable for pavement maintenance management planning. Block diagram of the system is shown in figure 1.

### Keywords:

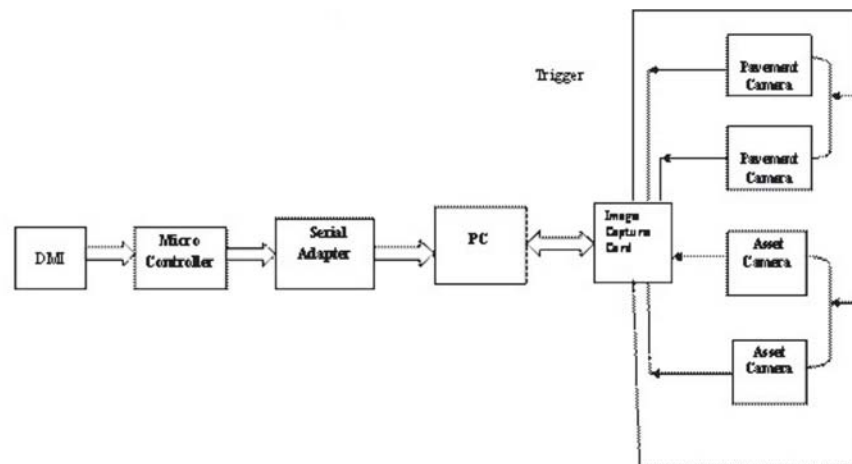


Fig 1: Block diagram of the system.

## Graphene Oxide Thin Films for Oral Cancer Immunosensor

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### Abstract

Oral cancer is the second most prevalent cancers in India. Despite of excellent developments in therapeutic modalities of oral cancer the survival rate is not encouraging. One of the major causes for failure of treatment modalities is late diagnosis of oral cancer. Here, we present a sensitive label-free immunosensor designed for the detection of oral cancer biomarker, Interleukin 8 (IL8). The immuno-bioelectrode has been fabricated on graphene oxide thin films on ITO by immobilizing anti-IL8, antibodies (Ab) on its surface through EDC-NHS binding chemistry. Graphene oxide with its high surface-to-volume ratio and various functional groups enables enhanced covalent binding of Ab at the surface thus contributing to efficient analyte detection. The graphene oxide films were characterized using X-ray Diffraction (XRD), Scanning Tunneling Microscopy (SEM) and Ultraviolet-Visible (UV-Vis) spectroscopy. The electrochemical activity of designed electrodes is studied using cyclic voltammetry revealing the quasi reversible behavior of graphene oxide. The standardization of bio-electrode was done by measuring different concentration of antigen in triplicate. Further, the maximum binding of Ab has been optimized by subjecting the electrode to different temperatures, time and pH. The fabricated immune-electrodes showed successful detection of analyte even at very low concentration ranges (25 fg/mL to 100 ng/mL). The designed electrochemical immunosensor represents a cost-effective technique for detection of oral cancer at earlier stages.

**Keywords:** Graphene oxide, Immunosensor, cyclic voltammetry

## Preparation, Optimization and *in vitro* Cytotoxicity Evaluation of Gold Nanoparticles

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### Abstract:

Gold nanoparticles (AuNPs) have attracted enormous scientific and technological interest due to their extraordinary physicochemical properties such as, high surface activity, chemical stability, and unique optical properties. Moreover, being biologically inert AuNPs are well documented to have low toxicity and have been extensively explored in the areas of imaging, drug delivery, diagnostics and cancer therapeutics. Owing to their versatile applications the standardization of AuNPs in relation to size, shape, stability and toxicity becomes imperative. The present study is focused on the synthesis along with optimization of AuNPs using well established citrate reduction method. The synthesized AuNPs have been characterized using Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), UV-Visible spectroscopy and dynamic light scattering (DLS). Results of UV-Vis spectroscopy exhibits a well-defined surface Plasmon resonance (SPR) absorption peak at 520 nm indicating the formation of spherical nanoparticles which is reinforced by TEM results revealing the formation of mono dispersed spherical nanoparticles of 15 nm  $\pm$  2 nm in size. The stability of AuNPs was studied periodically (every month) by recording the UV-Vis spectra and morphology by TEM. Further the DLS measurements were corroborated with UV-Vis and TEM observations. The optimized AuNPs were also analyzed for *in-vitro* cytotoxicity on Vero epithelial cell lines by MTT and NRU cell viability assays. The cell viability and IC-50 value with varied concentration of AuNPs has been calculated.

**Keywords:** Gold nanoparticles, standardization, *in-vitro* cytotoxicity, DLS, TEM.



## Time Dependent Variation of Correlated Color Temperature in Solid State Lighting

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### Abstract

Light Emitting Diodes (LEDs) are the latest and most exciting technological advancement in the lighting industry. LEDs are small and solid light bulbs, which are more rugged, durable, energy efficient with long lifetime in comparison to traditional light bulbs. However, their illumination characteristics are not as stable as for incandescent lamps. LED's photometric parameters vary with time due to change in junction temperature. Inconsistency in correlated color temperature (CCT) of white LEDs is also observed during initial burning time.

In the present paper, we studied the variation of CCT with time for commercially available different brands of LED bulbs.

We used three different brands white LED bulbs (Brand 1, Brand-2 and Brand-3) of same wattage, and their CCT and spectral power distribution curve were measured using colorimeter and spectrophotometer, respectively.

During initial period of glow, spectral power density in far blue region (380 nm-420 nm) increases and in green and red region (420 nm -700 nm) decreases with time, which results in increase in color temperature due to increase in blue component in white light. After ~30 min of illumination CCT for all three brands LED bulbs stabilize at respective particular value. However, difference in CCT from its initial to final stabilized value is different for different brand LED bulbs. It is also important to note that the initial and final value of CCT is also different for different brand LED bulb of same electrical rating.

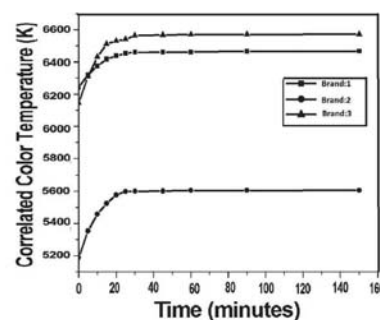


Fig.1. Variation in CCT with time.

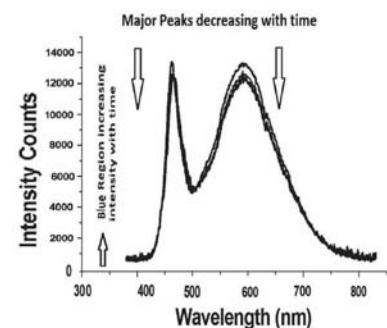


Fig.2. Variation in spectral power density with time.

**Keywords:** Correlated color temperature, LEDs, spectral power distribution.

## Ultra Low Power Optical Transmission Measurements in ND Filter

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### Abstract

Neutral density (ND) filters are very commonly used in various optics based experiments. In general, ND filter reduces the transmitted optical power by a specified fraction, irrespective of wavelength of light, and, they are considered to be used at high optical powers. Current research focus is towards measurements of optical power at ultra low level, i.e. few photon level and standardization of few photon source and detectors. As ND filters can be used to attenuate optical power to get it in few photon regime, study of optical transmission in ND filters at ultra low power is important for quantum optical metrology.

In the present work, we studied optical transmission in commercially available ND filters. The optical transmission characteristics at ultralow power (nW-mW) were analysed and effect of polarization was also studied on transmission characteristics. He-Ne lasers at 633 nm, 543 nm and 594 nm were used as light source. The intensity of laser light at different wavelengths was stabilized using liquid crystal based active optical device. The intensity of input light was controlled using polarizing variable beam splitter. The optical transmission through ND filter was sensitive to the polarization of input at ultralow power (Fig. 1).

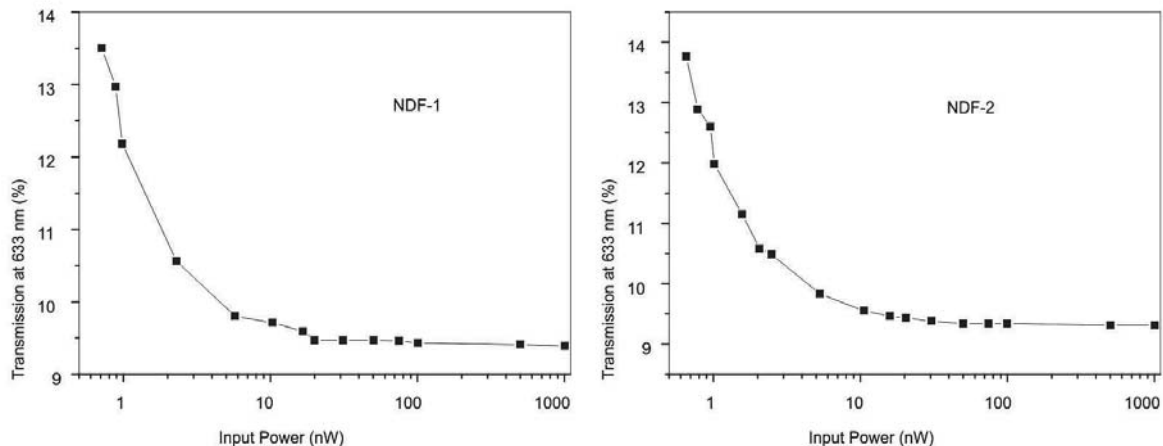


Fig.1. Optical transmission characteristics of two ND filters (NDF-1 and NDF-2) at 633 nm.

**Keywords:** Low power optical transmission, ND filter.

## Study of Luminous Flux Decay during Initial Burning Hours in LED Bulbs

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### Abstract

Light emitting diode (LED) based lighting is becoming popular due to several advantages over incandescent and fluorescent lamps, such as high energy efficiency, robustness and long lifetime. However, LED based light sources do not appear to be good candidate for making standard photometric sources as they show unstable emission behavior. As luminous flux is one the most important photometric quantities for illumination, study of temporal stability of luminous flux would be advantageous for their standardization.

In the present work, we studied variation of luminous flux of different commercially available same wattage LED bulbs, during initial hours just after switching them.

Luminous flux of all three brands LED bulb was measured using integrating sphere and their spectral power distribution was also measured using spectrophotometer. The measurements were taken at rated electrical parameters of LED bulbs continuously for 2.5 hours. Luminous flux initially decreases with time for half an hour and then stabilizes at particular respective value for all three brands. Spectral power distribution curves show decrement of 2 major peaks (peaks of host and phosphor material) with time during initial ~30 min, which appears to be the major cause of temporal decay of flux. Spectral power distribution in the wavelength region 720- 780 nm increases with time which may be due to rise in junction temperature of LED. Accurate measurement of luminous flux by either comparison method or by absolute method should be done after an hour warming up of LED lamps with proper alignments in the measurement set up.

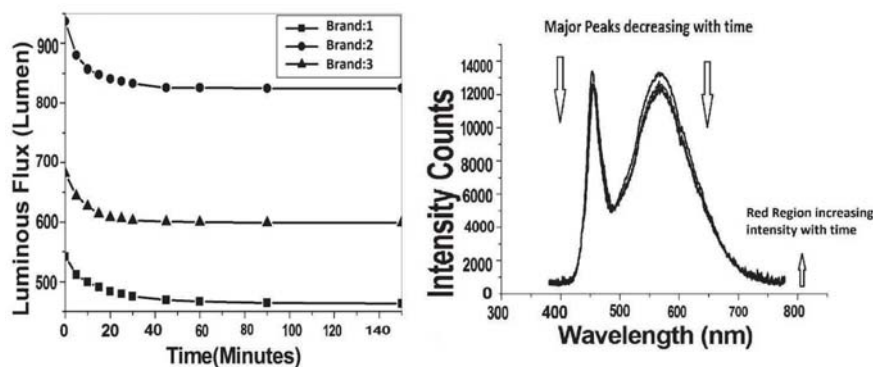


Fig.1. Variation of luminous flux with time. Fig.2. Variation in spectral power density with time.

**Keywords:** Luminous Flux, LED light.

## Investigation of Magnetic Property of Weights using Indigenous developed Magnetic Susceptometer at NPLI

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### Abstract

During the mass measurement, when a weight is placed on the weighing pan, there are three forces work on it, gravitational force, air buoyancy force and magnetic force. The resultant force is called apparent mass which is displayed by the weighing balance.

Gravitational force is due to mass of an object in a constant gravitational field.

Air buoyancy force is due to up-thrust on the weight depends upon the density of medium.

Magnetic forces can arise from the mutual interaction of two mass standards, as well as between a mass standard, the mass comparator being used for the weighing, and other magnetic objects in the vicinity. Magnetic force can adversely affect the weighing process. Without systematic investigation, the forces cannot be distinguished from the gravitational forces.

Hence, it is very important to determine the magnetic susceptibility of a weight before its mass measurement. A magnetic susceptometer has been indigenously developed at NPLI for this purpose. In this paper, we have discussed about measurement technique of magnetic susceptibility of a weight using this susceptometer.

**Keywords :** Magnetic susceptibility, magnetic force, susceptometer

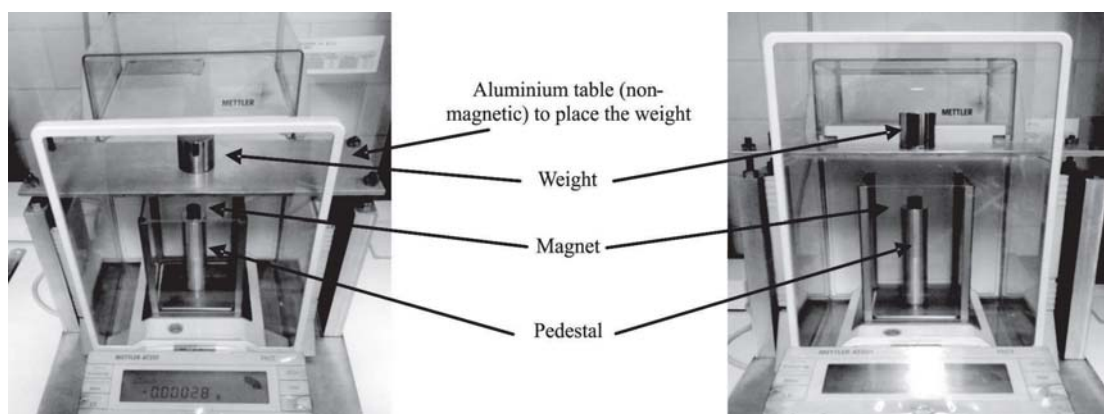


Fig.1 : Experimental set-up of magnetic susceptometer at NPLI

## Evaluation of Critical Geometrical Parameters and Alignment Corrections of Large Size Aerospace Systems

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### Abstract

Metrological assessment of geometrical, form parameters plays an important role in development of quality hardware of aerospace systems such as missiles. These parameters are critical for mission performance and system evaluation studies. High precision CNC Coordinate Measuring Machines (CMMs), Portable Laser Tracker Systems and Photogrammetry etc., are extensively used for evaluating geometrical, form parameters in alignment checks of large missile subsystems, assemblies and tooling. These high precision metrological tools can also be used for geometrical and alignment corrections of critical missile subsystems.

Alignment checks of typical integrated missile is an important activity carried out during development of missile system. The critical aerodynamic parameters viz. nose tip deviation, cant angle and orthogonality of wings & fins and propulsion parameters such as thrust axis misalignment are evaluated using geometrical features available on integrated missile. These aerodynamic and propulsion parameters are used for aerodynamic studies and predicting missile trajectory during pre-flight simulation analysis. The deviation in these values directly affects the missile performance during flight. In case of high deviations, the above parameters are corrected mechanically in order to meet the design requirements.

This paper brings out the applications and methodologies developed for evaluation and correction of geometrical and form parameters in alignment checks of large size integrated missiles, sub-assemblies and tooling.

**Keywords:** Missiles, Coordinate Measuring Machine (CMM), Geometrical, Form and Dimensional Parameters.

## Initial Temporal Variation of Correlated Color Temperature in Same Brand Different Wattage LED Bulbs

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### Abstract

In recent times LED lighting is the biggest achievement for both industrial and scientific field due to its high energy efficiency and low power consumption than that of fluorescent and incandescent lamps.

As illumination characteristics of LED depend on junction temperature, which changes during initial burning hours, temporal study of correlated color temperature (CCT) is important. Measurements CCT of same brand and different wattage LED bulbs are done using colorimeter. CCT for all the LED bulbs increases with time upto approximately 50 minutes. After 50 minutes of initial glow CCT saturates at respective particular value as shown in fig.1. This variable state is similar in nature for all LEDs irrespective of their wattage. Hence, for all LED based lightings, irrespective of their rated power, a minimum 1 hour of warm up should be done before calibration.

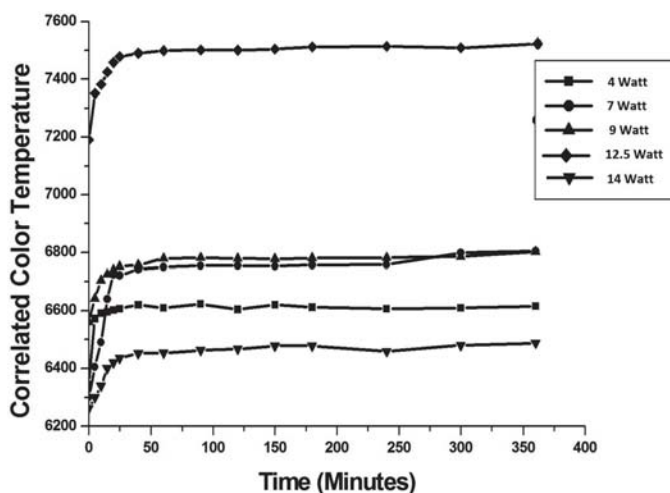


Fig.1. Variation of CCT of different wattage LED bulbs with time for initial hours just after switching on.

**Keywords:** Correlated Color Temperature, LED lighting.

## Nonlinear Optical Transmission in Sheet Polarizer in Ultralow Power Regime

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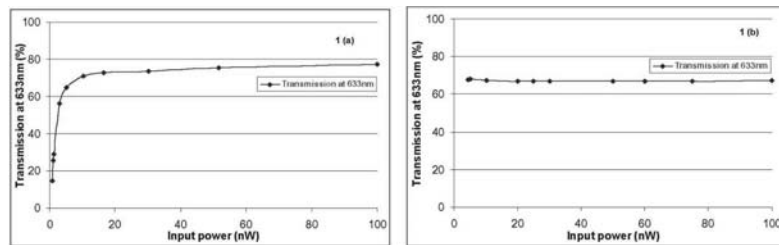
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### Abstract

Polarization is an inherent property of laser beams and plays vital role in characterizing material samples. Passive optical polarization components are often used to alter state of polarization of beams and to prepare them in specific states as required in applications. Continuously variable beam splitter (CVB), designed for a specific wavelength, is one of polarization components which is used to provide continuous variable attenuation in splitted p- and s- polarized components at its output. Current research focus is towards measurements of optical power at ultralow level, i.e. few photon level and standardization of few photon source and detectors. CVB can also be used to get attenuated polarized optical power in few photon regimes. Study of performances of such polarizing components namely, optical transmission, in ultralow power experimental setups is therefore, important for quantum optical metrology.

In the present study we observe nonlinear optical transmission of commercially available sheet polarizer, measured with CVB at ultralow power range (~nW). A vertically polarized 633nm He-Ne laser followed by spatial filter and liquid crystal based in-line laser power controller (LPC) is used to obtain intensity stabilized light beam with typical intensity stability of 0.05%.



*Fig.1. Intensity dependent optical transmission characteristics of a polarizer at ultralow powers*

Fig. 1 (a) shows transmission characteristic of an ordinary parallel sheet polarizer when the power of incident vertically polarized laser beam is controlled continuously with CVB and raised from 2 to 100nW in steps, keeping LPC intact. Transmission characteristic of the same polarizer is also noted for increasing input laser power from 5 to 100nW, adjusting LPC and keeping CVB intact, as depicted in Fig. 1 (b). It is interesting to note counter intuitive transmission result in the first case as optical transmission through polarizer is found sensitive to intensity of input polarized laser beam which is in contrast with the second case.

**Keywords:** Polarization, Low power optical transmission, Continuous variable beam splitter.

## Uncertainty Estimation in PM<sub>10</sub> Mass Measurement

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### Abstract

Measurements of particulate mass concentrations are important for regulatory and scientific reasons. Particulate matter  $\leq 10 \mu\text{m}$  (PM<sub>10</sub>) is one of the important parameters of the national ambient air quality standards (NAAQS) of most of the countries. In India, the regulatory limit of PM<sub>10</sub> in NAAQS is  $60 \mu\text{g m}^{-3}$  based on 24 hours time weighted average (i.e., annual average of minimum 104 samples in a year at a particular site taken twice in a week). In this work, we have determined and calculated the uncertainty components involved in the filter based sampling of PM<sub>10</sub> followed by its gravimetric determination of mass. Following the standards, we have measured PM<sub>10</sub> mass at a representative site, National Physical Laboratory (NPL) for a year from January 2014 - January 2015. The 24 hours time weighted average ( $n = 104$ ) for a year round measurement ranged from  $244 \pm 51$  to  $396 \pm 89 \mu\text{g/m}^3$ . During the measurement period, the particulate mass peak was observed during December to February months. Uncertainty components, i.e. conditioning of the filter (36%), charge effect (32%) and weighing (30%) are the major contributors to the total uncertainty budget in PM<sub>10</sub> mass measurement. Importantly, the sampling flow component shows  $< 1\%$  uncertainty contribution.

**Keywords:** PM<sub>10</sub>, NAAQS, mass measurements, uncertainty



## **An Inter-comparison Study between two Vickers Hardness Standard Machines**

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### **Abstract**

Precision hardness measurements is very much in need for several mechanical industries for the proper selection of materials for a given engineering application. Hardness is the measure of resistance offered by a material against any scratch or indentation. Determining and optimizing the hardness values of materials is highly desirable as it plays a crucial role in our daily life wherever wear and tear of moving parts having close tolerances is involved. The measurement of hardness values is absolutely inevitable for longer operational life of materials/ products, meeting specifications of product components for their global acceptance, development of novel materials having higher strength to weight ratio for potential applications in high technology industries like automobiles, aeronautics, railways, etc.

Industries use various kinds of materials such as metals, alloys, ceramics, plastics, rubber, etc. depending upon the application. Hardness values of these materials can be expressed on particular types of well established hardness scales like Rockwell, Vickers and Brinell. These scales are established by strictly adhering to the universally recognized documented procedures to unify the hardness measurement value of a substance universally acceptable. In CSIR-NPL We have established the hardness standardizing machines in the Rockwell, Vickers and Brinell scales to provide the traceability in hardness measurement to the user industries. In the present study we would like present the Vickers hardness measurements carried out by two different machines established at our laboratory on the selected HV scales in order to achieve the degree of equivalence in the hardness measurements made using these machines. For performing Vickers hardness measurements, a diamond indenter, in the form of a right pyramid with a square base and with an angle of 136° between opposite faces at the vertex, is forced into the surface of a test block and the diagonals of the indentation left in the surface after removal of the test force,  $F$ , is measured. The Vickers hardness is proportional to the ratio between the test force and the surface area of indentation which is expressed as

$$HV = \text{Constant} \quad (\text{Test force/ Surface area of indentation}),$$

For establishing the degree of equivalence of the machines, standard hardness blocks in different ranges are chosen on a few selected HV scales like HV10, HV20, HV30 and the measurements are made on these blocks using both the machines. In this presentation, the salient features of the machines, the repeatability shown by the machines, the average hardness values measured by the machines and their deviations with respect to the standard block and the En ratios are discussed.

**Key words :** Vickers scale, Hardness measurements, Primary hardness machine

## Reliable Measurements by Quality Control Testing and Calibration Laboratory – Kaizen / 5S Approach

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### Abstract

It has been found that application of Kaizen/5s theory in other areas results with great success because top management can see it as a way of "tuning" the quality control laboratory. It is a good way of interacting with the stakeholders and to understand their needs towards test. Also a new positive way of identifying improvements areas on test/calibration for quality control. All the technical personnel can impact / influence on what the improvement areas are and what one shall prioritize to work on. It verifies if testing/calibration team are working on the right improvement areas for quality control lab. In this paper a study made to verify the Kaizen / 5S theory to practices by lean concept which means elimination of waste /non value adding work and maintains flow (testing /calibration processes are made continuous) of production which is outcome of testing/calibration laboratory. All aforesaid efforts resulting towards eliminating waste , improving efficiency and increasing process consistency of laboratory.

- a. **Seiri or Sort.** Once the problem areas had been identified, the next task was to identify articles, tools, and materials that were either not required at all or were only used occasionally. Another group of items could be the items that were required but were being currently stored in the wrong place.
- b. **Seiton or set in order.** Everything that is needed to process a testing/calibration job should be placed for easy access. The items that were needed were put at their point of use - where they would best support their function. To evaluate which items would be directly utilized in the lab, the testing/calibration engineer and technical / quality manager were shown such items viz Equipment manual, Material Safety Data Sheets (MSDS), training manuals and Standard Operational Procedures (SOP) were provided dedicated shelves within a cabinet in the lab.
- c. **Seiso or shine.** 5S states that this phase is not just about shining or cleaning. It is actually a process of collecting data to know the root cause of waste, dirt, and damage. This would have to be a regular activity during the sustain stage
- d. **Seiketsu or standardize.** It was important to communicate the working philosophy to the lab management team. It is suggested to the team who agreed upon a new method of working that would keep the work place organized, clean, and functional. These included:
  1. Prioritize the use of tools and testing/calibration equipment found in the work place
  2. Find a location of these tools for easy access so that work flow is not disrupted
  3. Identify and document the sources of damage ,dirt or waste and how to avoid recurring
  4. Identify clearly all testing/calibration / equipment to make it a visual work place
- e. **Shitsuke or sustain.** It is not enough to implement only the four steps of 5S because the entire 5S effort would be futile if they cannot be sustained. "Practicing" 5S is more important and difficult than implementing.

This study involved the application of kaizen / 5S methodology in the laboratory management process. This implementation is likely to benefit the Quality control laboratory technicians and Quality Process Manager to increase the efficiency of managing the lab.

**Keywords:** Kaizen, Seiri, Seiton, Seiso, Seiketso, Shitsuke

## **Air Quality Measurements According to the National Ambient Air Quality Standards in Raipur City: A Comparison between Industrial and Urban Sites**

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### **Abstract**

Raipur city is known for its rapid urbanization since it becomes capital of Chhattisgarh state in 2001. Also it has a big industrial area located at northwest direction. Therefore, it is expected that the urban city is largely affected by the neighboring industrial emissions. Major industries are sponge iron, coal washeries, steel and metal related facilities, etc. Recent reports suggested that at the source site, the ambient parameters are mostly exceeding the regulatory limits, which may be the possible reason for bad air quality of the city. However, there is no long-term report available on the simultaneous air quality measurements at industrial and urban sites. In this work, we have collected air quality data (PM<sub>2.5</sub>, PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>x</sub>, CO) at Urla-Sarora Industrial area (2011 - 2015) and an urban site located at the heart of the city (2013-2015), and compared the data. Our results suggest that air quality of the urban city is mostly not affected by the industrial emissions, although the limits of pollutants especially particulate matter mostly twice the regulatory limits. In addition this study suggests that the air quality of Raipur city is better than that of metro-cities in India.

**Keywords:** Air quality, NAAQS, Industrial and urban site.

## Nanomagnetic Fluid Based High Precision Temperature Sensor

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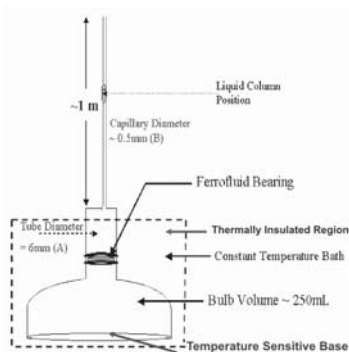
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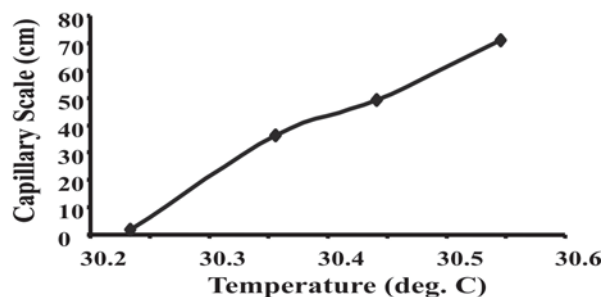
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### Abstract

In the realm of nanotechnology, nanomagnetic fluid or ferrofluid have the unique properties of sensation and actuation. This property of ferrofluid is utilized for developing electro-magnetically controlled devices. Nanomagnetic fluids or ferrofluids are the colloidal suspension of superparamagnetic nanoparticles dispersed in a suitable carrier medium. A highly sensitive temperature sensor (Fig. 1) using ferrofluid based magnetic bearing has been designed. The novelty of the device lies on the perfect sealing with low friction of magnetic bearing ( $\mu \approx 0.008$ ). The device is based on the principal of the ideal gas law. The permanent magnet with ferrofluid bearing has been used as a piston in the device which responds to a slight change in glass bulb temperature of the device. At constant pressure a temperature variation of 0.4 degree causes a variation of 75 cm in the position of liquid column in the capillary of the device. Further, the same has been digitized using calibrated devices giving a variation of 400 mV has been observed in the output of the device corresponding to a temperature variation of 1°. Thus, the device is highly sensitive with sensitivity of 2.5mK/V and can be used where high accuracy in temperature measurements is required. The device is capable of finding many useful applications viz. standards and the calibration of thermometers.



**Fig. 1 :** The diagram of the temperature sensing device with visual scale output.



**Fig. 2:** Graphical representations of the temperature sensor output on visual scale.

**Keywords:** Ferrofluid; Temperature sensor, Friction.

## The Effect of Dilution on Dipolar Interaction and Viscoelastic Behavior of Magnetic Nanofluid

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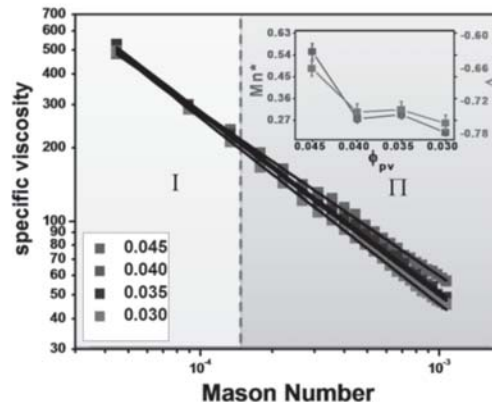
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### Abstract

The structural and magnetic investigations were carried out on Fe<sub>3</sub>O<sub>4</sub> based magnetic Nanofluid (MNF) using XRD, HRTEM and VSM. The changes in viscoelastic properties of different particle volume fraction samples were observed by Magneto-Rheometer. The results show that yield stress is directly proportional to particle volume fraction confirmed by Bingham law and the Mason number (Mn). The Mn provides a good scaling of the data in the steady simple shear flow regime. At low Mn values, two different behaviors are observed depending on the MNF formulation and magnetic field strength applied: (i) either the viscosity monotonically increases with decreasing shear rate suggesting the existence of a yield stress (ii) or a low-shear plateau is reached. At medium Mn values, a power law behavior. Further the couplings constant calculate the dipole -dipole interaction between the particles with increases the applied magnetic field becomes stronger with increases the particle volume fraction of MNF to 0.045.

The magnetic field effect on chain-like structure formation can be understood in terms of ratio of the hydrodynamic to the magnetic force known as Mason number [1].

$$Mn = \frac{\eta c \gamma}{2\mu_0 \mu_c \beta^2 H^2} \quad [1]$$



**Keywords :** Ferrofluid, Mason number, Shear rate.

## Reference Material for Calibration Standards of Electron Microscopes

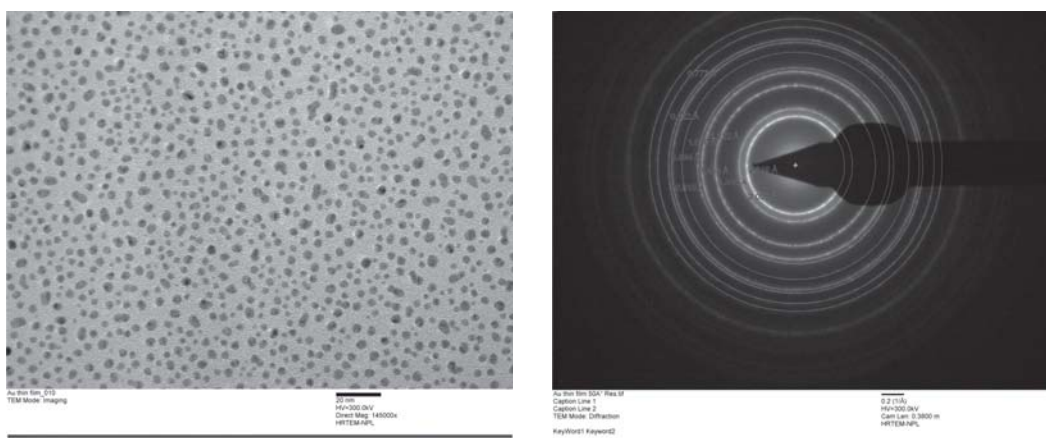
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### Abstract

Transmission electron microscopy (TEM) is a unique technique that allows detailed microstructural examination through high resolution and high magnification, in real and reciprocal space imaging to identify phases, lattices, defects, particle shape and size, etc. at nano and sub-nano scale. The ability and accuracy of the electron microscope depends on the magnification and the resolution of the microscope. Hence in order to achieve high accuracy measurement results from the electron microscopic examination, a standard specimen is required to calibrate the camera constant, and the magnification of the electron microscope. The resolution of TEM and HRTEM (high resolution TEM) can be evaluated by lattice imaging of the standard Au and Ag nano particles. Hence, in the present study it is proposed to synthesize highly stable Au and Ag nano particles based on low cost specimen preparation for electron microscope calibration using physical route. Several specimens of Au and Ag nano-particles have been prepared by physical route on carbon coated TEM grids. In this process, thermal evaporation was employed to prepare nano-structured thin films of Au under high vacuum conditions and have been deposited onto NaCl crystal and carbon coated Ni and Cu grids. Synthesis parameters have been optimized to grow uniformly distributed nanoparticles of Au and Ag. A detailed electron microscopy was carried out to record the images and corresponding selected area electron diffraction patterns (SAEDPs). Uniform Au nano-particles of about 2 to 5 nm are observed in electron microscopy images. Diffraction planes identified are 111, 200, 311 and 331 of Au matching with the standard JCPDF data.



TEM image (a) and corresponding electron diffraction pattern (b) of Au nano-particles.

**Keywords:**

## **Mismatch Transfer Standard: S-parameter Analysis of Attenuators Followed by Short**

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### **Abstract**

In the present paper three different attenuators (3 dB, 6 dB and 10 dB) followed by short have been analyzed as mismatch transfer standard for frequency range from 100 MHz to 18 GHz. Scattering parameter analysis have been carried out for reflection coefficient along with phase measurement. Measured results have been compared with existing mismatch standards. The results are in good agreement with respect to existing mismatch standards. VSWR values have been given to 3.0, 1.67 and 1.22 against 3dB, 6dB and 10 dB attenuator followed by short respectively with maximum expanded uncertainty  $\pm 0.04$ . Proposed method is capable to eliminate the requirement of mismatch transfer standard which is essential in VNA (Vector Network Analyzer) measurement and used as verification kit.

**Keywords:** VNA, Attenuator Followed by Short, S-parameters, Mismatch Standard Set

## Accuracy in Analysis of Cd, Cr and Pb in High Strength Matrix Waste Water

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### Abstract

Cadmium (Cd), Chromium (Cr) and Lead (Pb) are highly toxic metals released as effluents by industrial activities. Cd consumption may lead to disease called itai-itai whereas Cr is known to cause mutagenic effects and allergic contact dermatitis. Pb affects the central nervous system causing several learning disabilities. According to Indian standard specification for drinking water (IS: 10500:2012), the permissible limits for Cd, Cr and Pb are 0.003 mg/L, 0.05 mg/L and 0.01 mg/L, respectively. The Environment (Protection) Rules, 1986, CPCB has delineated the treated effluent discharge standard into inland surface waters for Cd, Cr and Pb as 0.2 mg/L, 0.1 mg/L and 0.1 mg/L, respectively for inorganic chemical industries. The low permissible concentration limit demands the analysis to be accurate. Our paper describes the study of trace metals in a complex matrix waste water and natural water by Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES). This analytical method should be robust for both water as well wastewater matrix. The effect of matrix components and interferences present in wastewaters are well documented in ISO/TC 147/SC2 and USEPA Method 200.7. The Limit of Blank (LOB) for Cd, Cr and Pb is found to be 0.0003 mg/L, 0.0010 mg/L and 0.0015 mg/L, respectively. Limit of detection (LOD) for Cd, Cr and Pb is found to be 0.0005 mg/L, 0.0014 mg/L and 0.0022 mg/L, respectively. Limit of quantitation (LOQ) for Cd, Cr and Pb is found to be 0.0011 mg/L, 0.0036 mg/L and 0.0060 mg/L, respectively. The precision and confidence in such measurements can be determined with laboratory fortified / matrix matched standards. Quality control was performed by standard addition for determining accuracy as reported in "Standard method for examination of water and Wastewater, 20<sup>th</sup> edition". High matrix concentrations in waste water leads to interference in analysis and hence the computation showed less recovery of analytes. On the other hand, ground water samples showed better recovery of analytes due to absence of matrix effect. The acceptable % Recovery of analyte is 85-115 %. The elimination of matrix effect was attempted by dilution of matrix and using matrix matched standards.

**Keywords:** ICP-OES, Wastewater matrix, Accuracy, Uncertainty.



## Validation of 6½ Digits Precision Digital Multimeter using Labview Platform for Apex Level Calibration

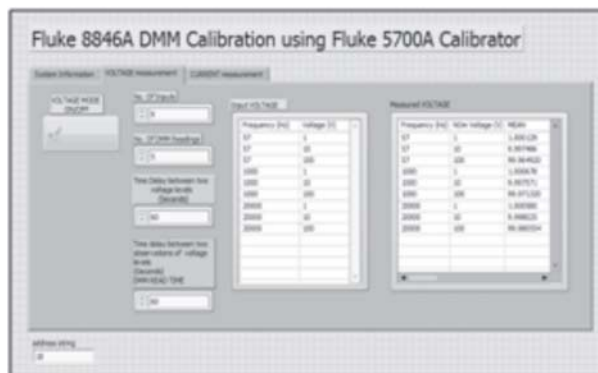
**Sunidhi Luthra, Swati Kumari, Bijendra Pal, Saood Ahmad, P.S. Negi and V.N. Ojha**

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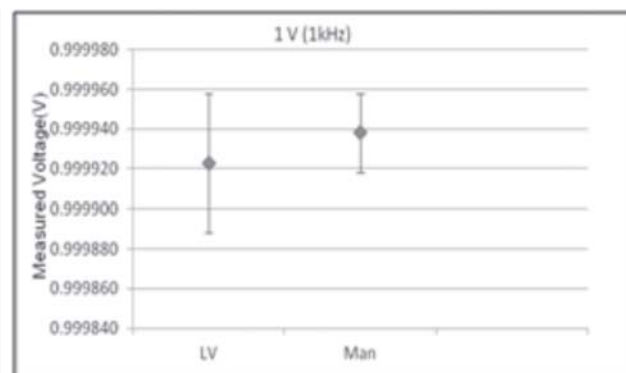
(\*Email : madaansunidhi@nplindia.org)

### Abstract

NPLI (National Physical Laboratory, India) being an NMI (National Metrological Institute) has the responsibility to establish, maintain and update the National standards, Reference standards and working standards by providing Apex Level calibration facility to laboratories (viz. STQC, BEL, BHEL etc) thus establishing traceability in the country. NPLI maintains a bank of Multijunction Thermal Converters as the National (primary) Standard for accurate and precise measurement of Low frequency Voltage and Current. The thermal devices are then used to calibrate precision AC Calibrator and Digital Multimeters. This paper presents a direct calibration technique for calibrating a Digital Multimeters through precision AC calibrator using LabView platform. The platform offers plug-and-play drivers for text based controls, hence it is user-friendly. The basic building block of programs written in LabView is Virtual instrument i.e. VI. Each VI corresponds to an instrument operation viz. reading, triggering, and configuring measurements from the instrument. The program once written in LabView helps the users to get start with their instrument by just feeding the data inputs from their computer. The measurement results for manual mode and automation mode are compared. The results at 1V 1kHz are shown in Fig.2



**Fig.1** Front Panel of LabView(LV)



**Fig.2** Measurement Results at 1V

The measured LF voltage at the desired calibration points 1V, 10V and 100V for three frequencies (57Hz, 1 kHz and 100 kHz) using LabView program was found in good agreement with manual measurement, thus validate the program written in LabView. Efforts are going on to further enhance the measurement software for LF Current parameter.

**Keywords:** DMM, LabView, Low frequency voltage and current

## Evaluation of trends in physiological parameters variation of children during rice crop residue burning seasons

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### Abstract

According to World Health Organisation (WHO) report, Agriculture Crop Residue Burning (ACRB) is the second largest source of ambient air contamination after industrial pollution. ACRB is episodic and this activity releases a huge amount of gaseous pollutants and respirable Particulate Matters (PMs) having size  $PM_{10}$  and  $PM_{2.5}$ . Toxicologically, raised level of PMs can cause adverse effects like asthma cardiopulmonary disorders etc. on health level of human subjects of all age groups especially children. Punjab is the second largest grain producer of INDIA. Rice and Wheat are the two main cyclic crops of this region. From previous findings, it was observed that Rice crop residue burning seasons have more level of mass concentration than any other crop burning seasons. 75% of rice crop has unused residue waste. As per sensitive cyclic process of crops in the fields, the waste get disposed of by burning them in the open fields. This practice releases a huge amount of harmful respirable particulate matters having size  $PM_{10}$  and  $PM_{2.5}$ . The impact of two consecutive burning seasons on the children health has been quantified for the period September 2013 to February 2014 and September 2014 to February 2015. Three strategically important sites (having maximum area under cultivation) Amritsar, Ludhiana and MandiGobindgarh were selected for fortnightly sampling and collection of data in Punjab state. 50 healthy volunteers (male and female) having age between 10 to 16 years were selected from each site as per American Thoracic Society (ATS) guidelines. A portable aerosol spectrometer monitor was used to measure the mass concentration level and spirometer was used to measure the physiological parameters like Forced Vital capacity (FVC), Forced Expiratory volume in one second (FEV1), Peak Expiratory Flow (PEF), Forced Expiratory Flow (FEF<sub>25-75%</sub>) of selected children. For both seasons, the variation in  $PM_{10}$  was from 64 to 149  $\mu g m^{-3}$  and  $PM_{2.5}$  levels varied from 43 to 101  $\mu g m^{-3}$ . A negative correlation was measured between increased level of PM concentration and physiological parameters of children in both burning periods. Statistically, 3 to 7% fall was observed in FVC which was higher than PEF (3 to 4%), FEV1 (1 to 3%) and FEF<sub>25-75%</sub> (1 to 3 %) in both seasons at all sites. Among the sites, Mandi Gobindgarh had 21 to 40% more concentration of PMs than Amritsar and Ludhiana and had more negative impact on subjects in burning seasons. Results having p-value <0.05 were considered significant. The results reveal that burning episodes seems to be an extreme burden for physiological parameters of children who are in growing stage. This may be the reason for any permanent disorder in human subjects at pre stage of age.

**Keywords:** Rice crop residue burning, Children, Particulate matters, Physiological parameters

## Establishment of Chilled Mirror Hygrometer as Reference Standard for Dew/Frost Point Measurement at NPL, India

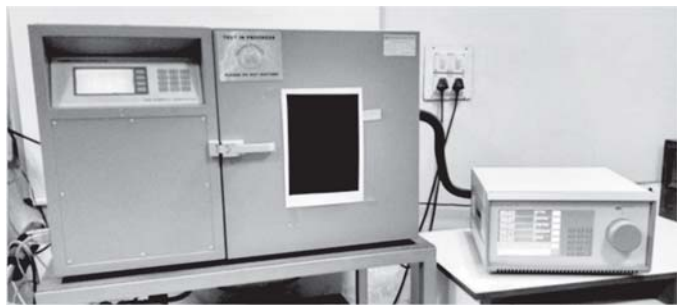
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### Abstract

The reliable and accurate measurement of humidity parameters such as relative humidity, moisture content, dew point and frost point are very essential because it affects various physical, chemical and biological processes. India being the agricultural economy with progressive industrial sector, there is an increased demand for the calibration of dew and frost point measuring devices. At NPL, India we have the fully automated humidity generator Model 2500 from Thunder Scientific for the calibration of hygrometers in the range from 10% RH to 95% RH and temperatures from 10 °C to 70 °C. This system has been made traceable in-house with the traceability from primary standards of temperature and pressure and measures the relative humidity with the uncertainty of  $\pm 0.3$  %RH and  $\pm 0.02$  °C, respectively. Recently, we have established the state-of-the-art chilled mirror hygrometer Model 373 from RH System for the measurement of dew/frost point in the temperature range from -50 °C FP to 70 °C DP. Model 373 relies on proven optically detected chilled mirror technique. It has a simple construction of metal mirror which is peltier cooled and surface temperature is measured by high precision platinum resistance thermometer (PRT). The intelligent optical control loop measures the direct reflection from the mirror surface, where the temperature at which the humid carrier gas forms a constant layer of water droplets on mirror surface it measures as dew point temperature, and when the constant layer of ice crystals is formed the reflection determines it as frost point temperature. Most of the leading NMIs use chilled mirror as reference standard for the high precision measurement of dew/frost point temperatures. In the present investigation, we have used chilled mirror hygrometer Model 373 as reference standard and Model 2500 as humidity generator to measure the dew/frost point devices by comparison calibration method. The detailed results are presented as a case study in this paper.



**Fig. 1.** Experimental set-up for the dew point measurement using chilled mirror hygrometer.

**Keywords:** Chilled mirror hygrometer, relative humidity, dew point, frost point

## HRTEM for Nano metrology

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### Abstract

Property of materials at nanoscale becomes size dependent. As the products made of nanomaterials are increasing in numbers in the market, it is necessary to have a standard for the nanomaterials. This will help in global marketing, ease of acceptance of the product and thus innovation. The standard in nanotechnology will also help in studying the effect of nanomaterials on the health of living entities. In order to have a standard for nanomaterials, materials need to be characterized by different techniques and the data needs to be calibrated. Transmission electron microscope provides a direct imaging method. In TEM, particle dimension is determined by the projection of the particle outline onto a two-dimensional image plane. The crystal lattice images can serve as internal calibration standards. The resolution of TEM reaching in sub angstrom range, this can be one of the standard techniques for standardization of nanomaterials. The modern generation TEM is capable of sub-Angstrom imaging in both transmission and scanning mode technique development. TEM can provide information about particle size, size distribution, shape, structure etc. Electron energy loss spectroscopy (EELS) and EDAX attached with TEM can provide the chemical mapping. Using EELS and EDAX, 3D spectroscopic identification of location and elemental identities of all atoms in a small nanostructure can be obtained. For the multilayer structures, the method can provide the information regarding the thickness of various layers and interfaces. There are a number of challenges to using this technique including careful sample preparation and choice of imaging conditions. Traditional techniques of dimpling and ion milling provide large thin area with minimal artifacts. For films with poor adhesion, the focused ion beam can be used to prepare TEM samples. This is the only technique to know the crystalline and amorphous structure at the nanoscale. Thus, TEM based techniques offer superior spatial resolution and highly sensitive elemental analysis capabilities that can be exploited for metrology and materials characterization of sub-nanometer sized device. Various phenomena have been explained using the HRTEM techniques and these will be shown in the presentation.

**Keywords:** Nano technology, HRTEM, Nanoscale materials.

## Evaluation of Critical Geometrical Parameters and Alignment Corrections of Large Size Aerospace Systems

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### Abstract

Metrological assessment of geometrical, form parameters plays an important role in development of quality hardware of aerospace systems such as missiles. These parameters are critical for mission performance and system evaluation studies. High precision CNC Coordinate Measuring Machines (CMMs), Portable Laser Tracker Systems and Photogrammetry etc., are extensively used for evaluating geometrical, form parameters in alignment checks of large missile subsystems, assemblies and tooling. These high precision metrological tools can also be used for geometrical and alignment corrections of critical missile subsystems.

Alignment checks of typical integrated missile are an important activity carried out during development of missile system. The critical aerodynamic parameters viz. nose tip deviation, cant angle and orthogonality of wings & fins and propulsion parameters such as thrust axis misalignment are evaluated using geometrical features available on integrated missile. These aerodynamic and propulsion parameters are used for aerodynamic studies and predicting missile trajectory during pre-flight simulation analysis. The deviation in these values directly affects the missile performance during flight. In case of high deviations, the above parameters are corrected mechanically in order to meet the design requirements.

This paper brings out the applications and methodologies developed for evaluation and correction of geometrical and form parameters in alignment checks of large size integrated missiles, sub-assemblies and tooling.

**Keywords:** Missiles, Coordinate Measuring Machine (CMM), Geometrical, Form and Dimensional Parameters.

## **An Investigation on Importance of Time Synchronization to IST in India, to Serve PAN India PAN Network Concept**

**Pranalee P. Thorat\* and S. S. Rajput**

*Time & Frequency Division, CSIR-NPL, New Delhi, India-12*

(\*E-mail: thoratpp@nplindia.org)

### **Abstract**

With the revolution of Smartphone and 3G where speed is everything and almost anything can be done using them, Time synchronization has become extremely critical. Moreover as the application is used nationwide, a standard unique reference source to synchronize them all is unavoidable.

Along with this, for many agencies precise and accurate time synchronization is a crucial requirement. Indian Banking and Financial Sector, Security Services, Telecommunication Networks, Aviation Services, ATMs, Gigabyte National Knowledge Network, the Certifying Authorities are a few to name. For the perfect operational assistance of all these sectors precise time synchronization throughout India is the most fundamental requirement. As otherwise correlating two distributed events or tuning up two remote events will be impossible.

Time & frequency division in National Physical Laboratory (NPL) is responsible for the highest level of time and frequency measurements in India and keeping them traceable to the International Bureau of Weights and Measures (BIPM) using ultra-precise satellite links. These clocks are so accurate that they would lose or gain one second in about three lakh years. The traceability of our time scale with BIPM is at the level of few nanoseconds.

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But there are some other key sectors where mere these two services are insufficient. Also some sectors like armed forces or security services, other popular time synchronization techniques like Global Positioning System (GPS) can't be used. Hence to tackle such critical and extremely importance sectors, an extensive study has been conducted to get Indian Standard Time (IST) synchronization. Special solution has been worked out to serve their needs.

Few of them are named below.

1. **Controller of Certifying Authority(CCA)** - E-Commerce and E- Governance by Digital Signature
2. **Institute for Development & Research in Banking Technology [IDRBT]**- communication backbone named as INFINET to connect all banks in the public sector, private sector, cooperative, etc., and the premier financial institutions in the India
3. *Department of Telecommunication (DoT)*- Entire telecom network established by all the service providers will come under a single synchronisation reference having the required accuracy.
4. **National Knowledge Network (NKN) by National Informatics Center (NIC)** - Aimed to connect institutions/organizations carrying out research and development, Higher Education and Governance with speed of the order of multi Gigabits per second.

This paper discusses about the various IST Synchronization solutions presented to these critically important applications of these esteem organisations.

**Keywords:** IST, Traceability, Digital Signatures etc.

## **A New Wireless Printing Technology for Universal Testing Machine based on Raspberry PI.**

**R.V. Tambad<sup>1</sup>, P.P. Sangle<sup>2</sup> and K.A. Bohara<sup>2</sup>**

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*<sup>2</sup>Scientific research assistant (Fie Research Institute, Ichalkaranji, India)*

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### **Abstract**

A motivation behind this work is to provide a wireless printing capability for universal testing machines by means of raspberry pi. A universal testing machine is an amazing multi-purpose system which can perform many standard tensile and compression tests on materials, components, and structures. However, most of the UTM manufacturers still rely on the computers to initiate the printing of generated test data which makes whole system costly and bulky. An entirely different approach is introduced in this paper which will make effective use of latest technology , keeping the whole system simple and uncomplicated. Proposed new generation technique is to empower UTM with latest printing technology for test report documentation, being compatible with most of the contemporary printers (USB as well as wireless) in the market. Implementation of raspberry pi over PC makes the system Compact, fast yet cost-effective. With this newly added feature, it is also possible to store test result data in USB mass storage device. In near future it is possible to replace entire existing testing panel with this new system.

**Keywords:** Raspberry pi, UTM, Wireless printer.

## **Calibration of Reference Standard of Accelerometer Calibrator using Transfer Standard**

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*Calibration laboratory, Quality Assurance Group (Electricals & Electronics)*

*Gas Turbine Research Establishment*

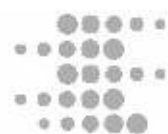
*Defence R&D Organisation, C.V. Raman Nagar, Bangalore-560093*

(\*E-mail: jitendrachauhan@gtr.e.drdo.in)

### **Abstract**

Calibration of Vibration sensors is very essential in the field of measurement and control. Accelerometers are used to test the aero engine on ground and to measure vibration levels of aero engine to check its airworthiness. The performance of these sensors has to be verified at regular intervals. In Calibration Laboratory, the calibration of these sensors is done using comparison method. The calibration setup consists of an electro-dynamic shaker which has an armature with an attached reference sensor. To maintain traceability, the reference sensor also needs to be calibrated at regular intervals. Due to technical limitations, the reference sensor could not be calibrated at national laboratories. Efforts were made to calibrate reference sensor in-house. A transfer standard with valid traceability to national labs was procured to calibrate the reference sensor. The aim was to calibrate accelerometer calibration system using transfer standard to maintain traceability.





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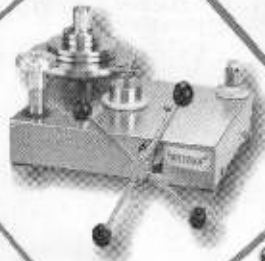
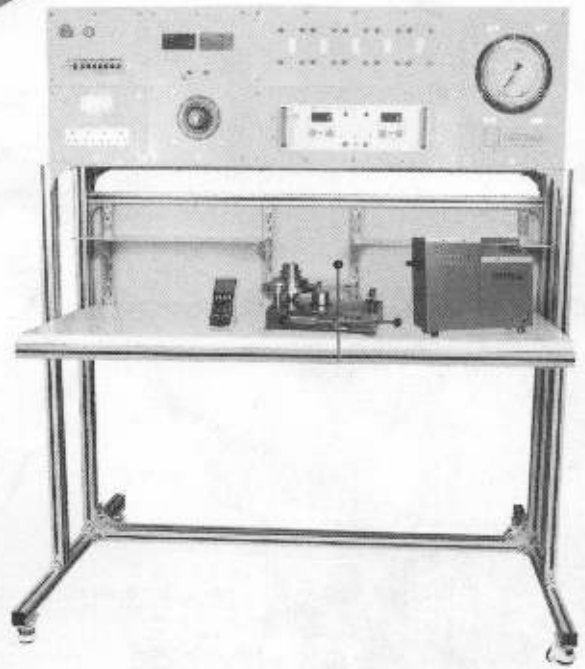
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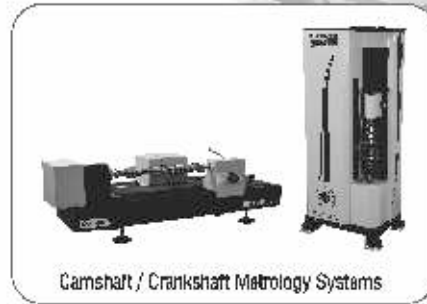
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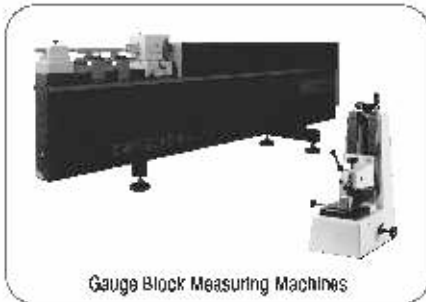
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## About Mitutoyo Corporation

Mitutoyo, a leading global manufacturer was founded in 1934 by Yehan Numata in Tokyo with one product The Micrometer. Mitutoyo's philosophy was to make the best mechanical micrometer in the world. This philosophy was expanded to include the widest product range by one manufacturer.

Today, Mitutoyo has the widest range of Metrology products, offering over 6000 products as integrated, computer-based metrology systems, where they can be interconnected to form closed-loop-measuring networks.

Mitutoyo is a global company with operations in over 22 countries and 140 locations; in order to provide service and expertise at the customer's doorstep.

Mitutoyo provides the most advanced products under the motto "Quality First", ranging from the sub-micron micrometer to the world's top class accuracy bridge type CNC CMM (LEGEX series)

## Nano Technology in Metrology

In the 21st century, from which great technological innovations such as nanotechnology are expected, Mitutoyo will continue in its role as the World-Leading Metrology company devoted to the pursuit of leading technologies that answer the changing needs of industry, providing not just measuring tools but also measurement-related technologies.

## About M<sup>3</sup> Solution Centres (\*M<sup>3</sup>=Mitutoyo, Measurement, Metrology)



Mitutoyo's M<sup>3</sup> solution centres are specifically designed to address the measurement related challenges from customers. Here, effective solutions to out of the ordinary requirements can be found through the company's products, in combination with consultations with Mitutoyo's metrology experts.

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The Mitutoyo Corporate Philosophy is essentially the perpetual 'core values' that our organization and employees uphold, and which unites all Mitutoyo companies worldwide.

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"To contribute to people's welfare through support of the advancement of Buddhist understanding"  
"To see that Mitutoyo excels in its field of Expertise and in its business conduct throughout the world"

### Our Management Principles

"To contribute to the well-being of society through precision measurement technologies"

### Our Corporate Motto

"Good environment, good people, good technique"

### Our Guiding Precepts

"Sincerity, thoughtfulness, determined spirit"

## About Mitutoyo South Asia Pvt. Ltd. (MSA)

Mitutoyo started selling small tools in India nearly 50 years ago. In 1989, an M<sup>3</sup> solution centre was opened- the first of its kind in India; supported by Japanese technicians in order to provide world class sales and service expertise at the customer's doorstep. This was followed by the opening of Mitutoyo South Asia Pvt. Ltd., a subsidiary in 1996; on global lines.

Mitutoyo South Asia Pvt. Ltd. (MSA) has 8 sales and service locations covering all major industrial belts in India. There are now 4 M<sup>3</sup> Solution Centres, strategically located across South Asia and a world class laboratory and calibration centre in New Delhi.

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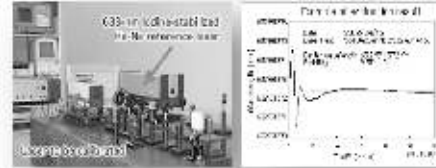
# Mitutoyo Proprietary Technologies & Equipment

MITUTOYO continuously emphasizes on R&D for new technologies and products that meet the needs of today's industries for higher precision, faster processing, and reduced power consumption. MITUTOYO products are manufactured using the company's own specialized machine tools and other high-tech production equipment, while being backed by a thorough-going quality control system.

## Evaluation Technology

### Mitutoyo standard laser

MITUTOYO maintains a light wavelength calibration system that uses a 633-nm iodine-stabilized He-Ne reference laser, similar to the type used by the Japanese government



Calibration Uncertainty:  
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MITUTOYO has developed ultra-high precision length measuring machines, which it used to measure the molds used for high precision scales and digital scales



Measuring Uncertainty (k=2):  
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Integrated Production in the clean room



Underground Laboratory (Kiyomizu Manufacturing Department)



3m vacuum-sealed sea box

## Electronics Technology

MITUTOYO not only designs and develops its own custom ICs, but also embeds them in various electronic modules



Design of Customized ICs



Customized 1-chip IC



Electronic Modules

## Mechanical Technology

CAD and CAE technologies are used with FEM analysis, cost model analysis, and thermal analysis to design and develop highly rigid, highly shock-resistant, high-quality measuring instruments noted for their high reliability



CMM



Microscope

## MEMS Technology

MEMS technology is being used to develop various types of sensors



ICP etching equipment for Si-MEMS



Application: eg. Micro-acceleration sensor

## Software Technology

Mitutoyo develops software for CMMs and many other kinds of measuring instruments



MCAT

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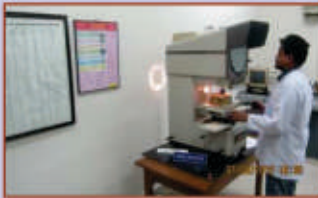
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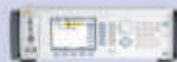
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- Temperature Calibration Baths, Dry-Well Calibrators, Infrared Calibrators, Thermocouple Furnaces
- Multifunction Process Calibrators
- Service and Training



### RF calibration

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- RF Calibration Custom System Solution
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- Air Data Calibration, Pitot / Static Primary Standard
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