

## Josephson voltage standard at National Physical Laboratory, New Delhi

A K GUPTA, N S NATARAJAN, V S TOMAR, N D KATARIA,  
V K BATRA, A V NARLIKAR and K CHANDRA

National Physical Laboratory, Hillside Road, New Delhi 110012, India

**Abstract.** A C Josephson effect is now used by several countries as the reference standard for the unit of d.c. voltage. This paper describes the work done at the National Physical Laboratory (NPL), New Delhi in the realization of the unit of volt based on the a.c Josephson effect. A voltage standard at 1 mV level using a Nb-Nb point contact junction has been established and the as-maintained volt based on a bank of standard cells has been intercompared against it using a 1 : 1000 voltage divider. The experimental set-up used in this comparison and the results of recent measurements are described. The overall uncertainty in assigning the value of emf to a standard cell is about 1 ppm. The as-maintained volt has been found to agree with the Josephson voltage within overall uncertainty.

**Keywords.** Josephson effect; voltage standard; superconductivity; superconducting devices.

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### 1. Introduction

The a.c. Josephson effect (Josephson 1962, 1964, 1965) is now used by several national laboratories (Field *et al* 1973; Harvey *et al* 1972; Melchert 1978; Hartland 1977; Witt *et al* 1983; Andreone *et al* 1983; Endo *et al* 1983; Wood and Dunn 1981) as the reference standard for the unit of d.c. voltage. The Josephson effect relates the voltage to the frequency, the most accurately known SI unit, through fundamental constants  $e$ , the charge of the electron and  $h$ , the Planck's constant. This voltage frequency relation is space- and time-invariant and forms the basis for the reference standard for the unit of volt. The earlier reference standard based on a bank of saturated Weston cadmium cells had unpredictable long-term drifts of the order of a few ppm and required periodic transportation to BIPM, France for intercomparison with their standard cells. Moreover, it was very difficult to know what portion of the difference between the values of the BIPM volt and that of the other laboratory was due to the drift in the emf of the BIPM cells. All these problems have been overcome with the development of the Josephson voltage standard. However, a bank of standard cells or a Zener-based electronic voltage standard is still maintained as the physical standard to represent the volt and is used for day-to-day calibration work. These physical standards are periodically calibrated against the Josephson voltage standard.