Scale Determination of Digital Levelling Systems Using a Vertical Comparator

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ABSTRACT

For high precision levelling digital levelling systems use 3m long staffs, where the code is etched on an invar band. The scale of the code is a function of the actual temperature of the invar band and a constant scale value. The latter is traditionally determined by 'staff calibration'.

Using digital levels the scale value could also be influenced by a scale value of the level (e.g. aging effects of the CCD). To check the behaviour of the whole levelling system a procedure known as 'system calibration' can be used. Thereby height readings are taken at different positions on the staff and compared with their 'true values', which are obtained by a laser interferometer. Critics have expressed their doubts about the usefulness of system calibration and they insist on the separate staff calibration.

Therefore we investigated the determination of the scale value of the staff by system calibration. For this purpose a staff was calibrated with one of the most accurate facilities for staff calibration at the Bundeswehr University Munich (UniBwM). A coded invar staff is mounted in a horizontal position and the edges of the code elements are automatically detected under control of a laser interferometer. The accuracy of the photoelectric edge detection is 0.7µm + L*0.4µm, with L being the position on the staff in meter. The determined scale value of the staff was 15.5±0.3ppm.

The system calibration was done with the new vertical comparator at the Graz University of Technology, also controlled by a laser interferometer. The internal precision of this vertical comparator is estimated better than ±4µm. For the system calibration the same staff and a brand-new Trimble DiNi12 digital level were used with the assumption that this new level has no scale value. The scale value of the system was determined with 15.0±0.3ppm. To prove the assumption (i.e. the DiNi12 has no scale value), further system calibration with two Zeiss DiNi11 and the same staff were carried out, yielding the same scale value as obtained with the DiNi12.

We were able to prove, that the system calibration of levelling systems using short sighting distances is capable of determining the composite scale value of the whole levelling system (staff and level) with a standard uncertainty of about 1ppm.

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