New Modular 10m-Bench System for Traceable Measurements of Steel Tapes and Rulers at TÜBİTAK

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Presented in Macroscale 2017 "Dimensional and related measurements at the macroscopic scale"

Abstract
Traceable line standard (tapes and rules) measurements are still one of the major parts of the dimensional metrology. Therefore following the old 5m-Bench system which has been used since 2003, it was decided to establish a new modular 10m-Bench system at the new industrial measurement laboratory (50 m long) of TUBİTAK UME. The idea behind the new system was a modular system construction that could be extended up to 50 m long when requested. A new design has been realized which can be extended to 50 m for measurements that require long distance Bench system such as 50 m.

The modular 10m-Bench system (Fig. 1) was designed and constructed by TUBİTAK UME Dimensional laboratory for calibration of all types of rules and tapes up to 10 m long (20 m long with stitching methods). All systems are located on a bench table specially designed and constructed by aluminium bars. The new system is mainly composed of 13 m rail system, mechanical parts, optical units and laser interferometer. The carriage movement is supplied with DC mini motor which is controlled either by measurement software user interface or by a joystick. The motorized carriage, on which a camera for probing of the scales and an optical reflector for the reference laser is placed, is located on rails. The image of the scale on tape or ruler taken by the camera is viewed on the computer screen with the help of a home-made software that has an ability to determine the middle position of the line automatically. Therefore the system can perform the probing process by simply placing the measured scales on the viewed target cross line with the help of a motorized carriage. The carriage movement is measured by a laser interferometer. 10 m Bench angular errors are measured by laser interferometer with angular optics. Effects resulting from angular errors have taken into account in the uncertainty evaluations. All cables in the 10 m bench system are guided by cable tray which is connected to the carriage. The developed software running under Windows environment also performs temperature measurement for required corrections. The measurement values are collected using the software and evaluation is done according to (OIML R 35-1), European legal metrology (73/362/EEC) standards, or with the user specifications. The overall uncertainty for the system is $U_{k=2} = [(75)^2 + (5xL)^2]^{1/2}$ µm, where L is the measured length of the tape or rule in meters.

Introduction

The new generation modular 10m-Bench system has been designed and constructed at the new industrial measurement laboratory. As in the previous 5m-Bench system, this new 10m-Bench also provides measurements that comply with the International (OIML R 35-1) and European legal metrology (73/362 / EEC) standards. The system is placed in an air-conditioned laboratory consist of a 50m-long corridor and equipped with two industrial type air conditioning systems which are located and operated in different rooms. Air is distributed to the laboratory through large air nozzles at the ceiling and exhausted from wall unit near the floor. The laboratory is in the middle of the whole building, therefore the location is very conservative. The materials and instruments used on the bench are considered to be insensitive to vibration, nevertheless the new building of UME as well as the 50 m long laboratory is designed and constructed as a vibration-proof concept. The geographical location where UME is established is very far from the industrial facilities, busy traffic roads and rail ways.

Figure 1. The view of 10m-Bench system

10m-Bench Measurement System Technical Properties

- Base construction made of 6 pcs special design aluminium frame table which is connected to each other. Two of them 2.5 m and the 4 pcs of them 2 m long. Base length is 13 m long.
- Rail system is 12 m long in two side of the top of the base construction.
- The optical units moves and take a position with carriage by micro DC motor
- Tape support and tape clamping-tensioning mechanism.
- An analogue black and white camera with a magnifying lens for Optical probing
- Length measurement system: HP 55292A laser interferometer is using with Michelson interferometer
- Temperature measurement system (3xPt100)
- Comprehensive software written in Visual Basic: The software has 3 main part. (Fig. 4-5)
  - It can control micro DC Motor by command button or by joystick
  - It reads data from laser interferometer control box (or you can use original HP software by externally.)
- It can take a video image from monochrome ethernet CCD camera and analyse centre of each line by image processing which use by binarization method.

Verification of the System

The calibration of the 10m-Bench system has been performed in different steps. We can examine them in the following steps.

- Detection of angular (Pitch and Yaw) errors of the carrier. It has been investigated using a laser interferometer angular optics.
- The affected the measurement accuracy due to the design of the carrier.
- Detection of error in the optical probe with a micrometer. It shows optical probing performance that has been performed in order to determine the accuracy of the system.

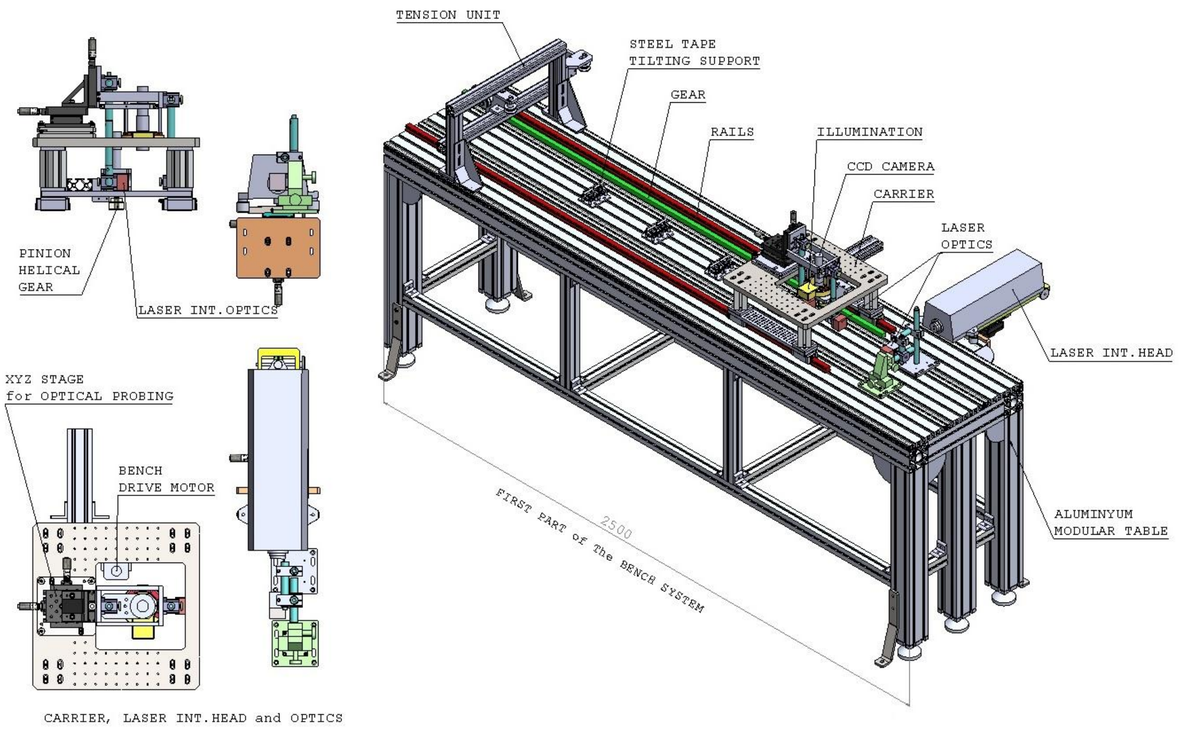

Figure 2. Details and First part of 10m-Bench measurement systems

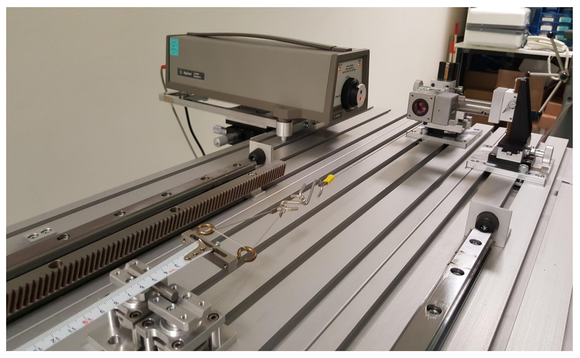

Figure 3. The main parts of front side of bench system

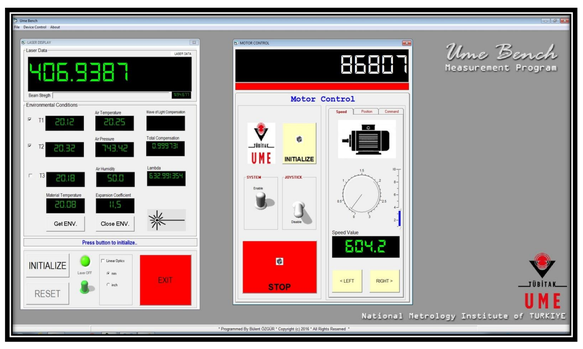

Figure 4. General view of the software

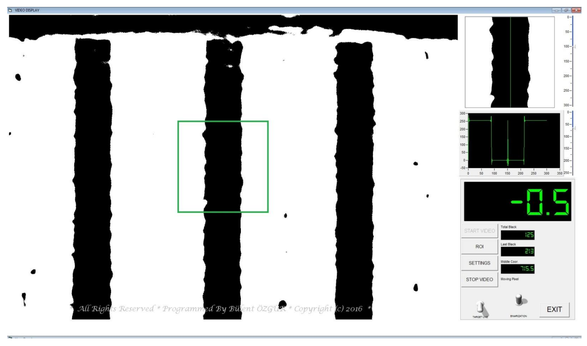

Figure 5. The view of image with binarization

Performance of the 10m-Bench Measurement System

The performance of the 10m-Bench System measurement system has been checked by 10 m steel tape which is calibrated by METAS at 2015 The steel tape has been placed on 10-m Bench System, so that the carriage could be positioned to perform each 500 mm length in the measurement range of (0 -10000) mm. The results are shown below. (Fig. 7)

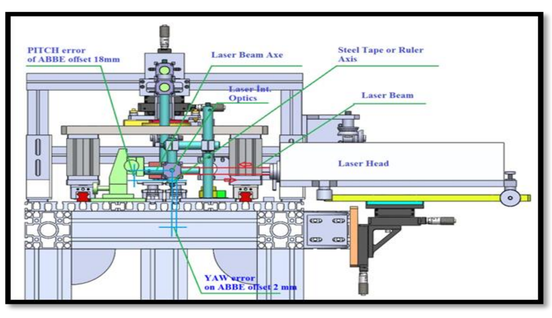

Figure 6. Section view of 10m-Bench design

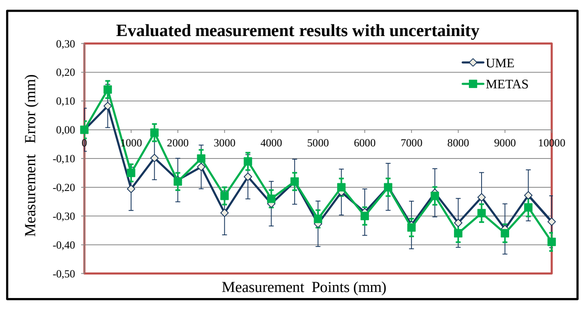

Figure 7. Evaluated measurement results with uncertainity

Conclusions

A motorized 10m-Bench constructed in TUBITAK UME for calibration of tapes and rulers were described. The device provides traceable calibration of tapes and rulers up to 10 m (up to 20 m with stitching methods) using a laser interferometer with an estimated expanded uncertainity of

$$U_{k=2}=[(75)^2+(5xL)^2]^{1/2}\ \mu m,\ (L=meter)$$

The 10m-Bench measuring system is a prototype for the 50m-Bench measuring system that is planned to be built in the coming years with the same modular structure. At the same time, the 10m-Bench system provides important information about the portable system design for future work.

The device is suitable for calibration and inspections of reference tapes and rulers in accordance with OIML R35 standards and the regulation prepared by the Ministry of Industry and commerce on the basis of the European Legal Metrology Standard 73/362/EEC Directive.

Acknowledgement
The authors would like to thank to Mr. Emre SONOLUK for his kind support during initialization of the project.