

MICROCONTROLLER-BASED CALIBRATION BENCH MODULE FOR USE IN SECONDARY STANDARD DOSIMETRY LAB (SSDL)

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مُستخلص

تستخدم وحدة طاولة المعايرة للتحكم في الموضع ودرجة الحرارة في غرفة الاختبارات في معمل المعايرة الثانوي (SSDL). إن الهدف من هذا العمل هو تصميم وتنفيذ نظام في الزمن الحقيقي لوحدة طاولة المعايرة بنظام تحكم منمَج للحصول على تحديد دقيق لموضع الكائنات المعرضة للإشعاع بغرض القياس. ويمثل نظام المعايرة المنفذ قاعدة آلية تتكون من نظام تحكم دقيق ودوائر الكترونية ومجموعة ميكانيكية. عن طريق التحكم في طاولة المعايرة من لوحة تحكم خارج غرفة الاختبار يحقق النظام تحديد مناسب لموضع العينة أمام حزمة إشعاع مركزية مقارنة بتحديد الموضع يدوياً. كما ينتج النظام قراءات مناسبة لدرجة حرارة غرفة الاختبار مقارنة بقراءات ميزان حرارة مرجعي. يؤدي هذا النظام إلى عمليات معايرة عالية الجودة و تقليل زمن تعرض الأشخاص للإشعاع ومن ثم تقديم خدمة جيدة في مجال الوقاية من الإشعاع.

ABSTRACT

The calibration Bench Module is used for controlling the position and monitoring the examination room temperature in Secondary Standard Dosimetry Labs (SSDLs). The objective of this work is to design and implement a real time calibration bench module with an embedded control system to provide a precise position for the objects to be irradiated for radiation metrology purpose. The implemented calibration bench represents a robotic platform, which consists of a microcontroller, electrical circuits and a mechanical assembly. By controlling the calibration bench from a control panel outside the examination room the system results suitable position allocation for the sample against the radiation central beam compared to manual positioning. It also results suitable readings of the examination room temperature compared to readings of a reference thermometer. The resultant system leads to high quality of the calibration process and less exposure time for the personnel i.e., good radiation protection.

Keywords: Automatic control, calibration bench, secondary standard dosimetry lab, SSDL

1. INTRODUCTION

X-rays and other forms of ionizing radiation are powerful tools for use in medical and industrial applications with a minimum risk. However, High accuracy in the radiation measurements is essential in assessing whether a particular radiation monitoring instrument is adequate for its intended use.

So each instrument should be calibrated and recalibrated periodically.

To maintain the calibration problem WHO and IAEA established a network of Secondary Standards calibration laboratories equipped with a reference instrument calibrated by one of the primary laboratories, which belongs to IAEA.

Most of SSDLs are fully human piloted in positioning the calibration bench, since the distance between the source and the object to be irradiated (on the calibration bench) is the most important factor. It has a significant magnitude influence on dose measurement which



needs high accuracy as it depends on the inverse square law. So, using a controlled system will be speedy and more accurate. The examination room temperature is another factor which needs to be monitored for its importance in dose measurements and calibration consideration. The calibration bench should meet the requirements of the lab to achieve the radiation protection goal [1].

2. SYSTEM DESIGN

An embedded control system is designed to provide a precise position for the objects to be irradiated for radiation metrology purposes in SSDL. The system consists of both hardware and software parts. Software is discussed in section 5.

The block diagram in Figure 1 shows the hardware architecture of the microcontroller-based system. It consists of both mechanical and electronic parts.

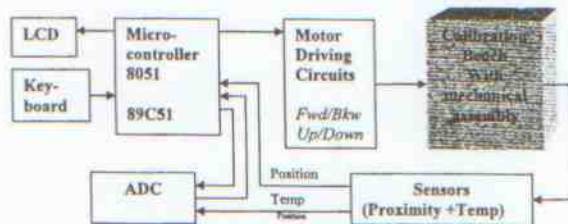


Figure 1: System Block Diagram

The microcontroller is the heart of the system, and then comes the user interface device, which consists of a keyboard for the user commands and an LCD to display the current machine status and the examination room temperature. The sensors and ADC handle and process the proximity and temperature data and send them to the microcontroller.

The motor driving section is an H-bridge configuration of power MOSFET transistors used to drive the motors bi-directionally via the microcontroller through the opto-coupler.

3. CALIBRATION BENCH SYSTEM IMPLEMENTATION

The implemented bench module represents a robotic platform as shown in Figure 2.

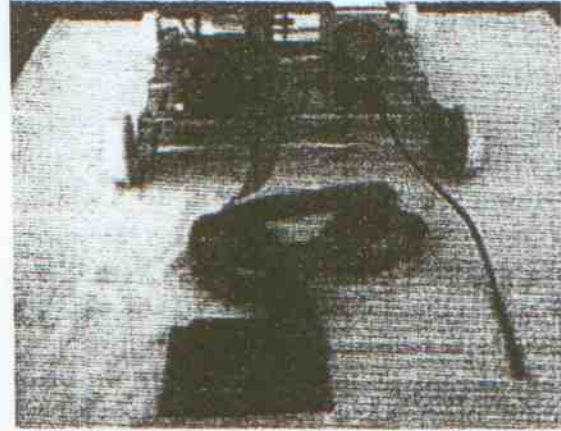


Figure 2: Robotic Platform

The mechanical assembly consists of four wheels and two motor assemblies for longitudinal and vertical motions; the base is made to fit the mechanical parts, control board and the power supply unit.

Essentially the controller consists of code storage memory, interface to obtain sensory data and ancillary components.. The proximity sensor is located on one of the bench wheels and the temperature sensor is located on the control board. On the top of the bench a TV camera is located to monitor the object position and display the current reading of the sample. The camera system represents a separate monitoring system just mounted on the bench. The power unit is a switch mode power supply (SMPS) which provides power to the system.

4. CONTROL SYSTEM DESCRIPTION

The on-board Bench system is designed using the AT89C51 microcontroller from Atmel which is high-performance CMOS, 8-bit microcomputer with 4Kbytes of flash programmable and erasable read only memory (EPROM). The device is compatible with the industry-standard



MCS-51 instruction set and spinout. The AT89C51 is a powerful microcomputer which provides a highly-flexible and cost effective solution to many embedded control applications [2].

An 8051 microcontroller provides signals to control the system and achieve the position of the Bench which is detected by the inductive proximity sensor (M30, 8mm, Metal)[3]. Another function of the microcontroller is to process data of the temperature sensor (Precision Centigrade LM35) [4]. Two H-bridge power FET transistors arrays provide the driving power and direction control of the two motors, while the microcontroller controls the H-bridge through the optisolators.

Electronics workbench software packages are used for testing the schematic design, and Printed Circuit Boards (PCB) design.

5. SOFTWARE DESCRIPTION

To perform the functions of the calibration bench, software is developed by using C language with the KEIL Compiler. This system continuously collects data from the sensors and the possible human inputs, processes this data, and then generates commands. Human inputs are decoded through the driving of the motors. These inputs are conditioned, based on sensors data. The system is designed to allow the current state of the system to be displayed on the LCD. Emulator (In circuit) is used for running the test programs, and then finally the EPROM Programmer is used to copy the code into the code memory.

6. RESULTS

The Calibration Bench Module is examined, and the results of the outputs are distances and temperature readings.

LCD displays the temperature at the upper right side and the machine status on the lower row, when the machine is moving longitudinally LCD displays the increment of the distance counter till it reaches the desired distance. In case of vertical (up/down) movement the LCD shows the words "Moving Upward" or "Moving Downward".

As shown in Table (1) the distance/position has a slight deviation due to proximity sensor resolution which affects the accuracy of positions.

Table 1: Set Distance Vs Measured distance

No	Set Distance	Measured Distance
1	100cm	100cm
2	120cm	120cm
3	190cm	189cm
4	250cm	250.4cm
5	320cm	320.6cm

Examination room temperature is well adjusted with the help of reference thermometer and the variable resistance located on the control Board Table (2) shows the bench module temperature reading vs. the reference meter reading.

Table 2: Temperature Readings

No	Bench module temp reading	Reference meter reading
1	38°C	37.8°C
2	35°C	34.7°C
3	36°C	35.9°C
4	38°C	38.02°C
5	32°C	32.01°C

So, comparisons in the above tables show that the overall expected outcomes and results are achieved with acceptable error ratio that is $\pm 0.40\%$ in the distance and ± 0.25 in temperature.



