Development of the automated bunker door by using a microcontroller-system

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Abstract. The new low energy electron beam accelerator bunker was designed and built locally to allocate a 500 keV electron beam accelerator at Block 43T in Malaysian Nuclear Agency. This bunker is equipped with a locally made radiation shielding door of 10 tons. Originally, this door is moving manually by a wheel and fitted with a gear system. However, it is still heavy and need longer time to operate it manually. To overcome those issues, a new automated control system has been designed and developed. In this paper, the complete steps and design of automated control system based on the microcontroller (PIC16F84A) is described.

1. Introduction
A bunker was completely constructed in 43T building in Malaysian Nuclear Agency. The bunker was built for the use of electron beam (EB) accelerator which has a capacity of 500 keV. This bunker is equipped with plug-in type door that acts as a shielding and it has an estimated weight of 10 tons.

The weakness of the existing system of the bunker door is the operations for opening and closing the door which are fully manually operated. Consequently, more time is needed to open and close the door which is not effective given the limited manpower available. For that reason, the bunker door operating system is upgraded so that it is more effective and utilises minimal manpower. To overcome and solve these problems, a new system has been developed to upgrade from manually operated to automated motor controller system for the bunker door. The system is built based on using microcontroller PIC16F84A.

2. Bunker design
The building that placed the EB accelerator and its auxiliaries can be divided into three areas. The areas are working area, ventilation room and irradiation room (bunker). The working area includes control panel monitoring and the open spaces inside the building. These working area is classified as clean area in terms of radiation safety. The ventilation room is where the blower and the exhaust motor are placed.

The bunker was designed to prevent radiation from entering working areas. It housed EB accelerator, high voltage transformers and also ventilation system. This bunker was constructed using
high density concrete, with thickness of 85 cm and 500 cm high. During operation, the bunker door must be secured and interlocked with the EB accelerator. Figure 1 shows the layout of EB Bunker.

![Layout of EB Bunker](image)

**Figure 1.** Layout of EB Bunker.

3. **Microcontroller PIC16F84A**

Microcontroller (μc) refers to computer chips that have been created to control electronic devices. It is one of the branch micro-conscious processing operations that is easy and with low cost-effective. The microcontroller generally contains all the memory and interface I/O for simple application.

The flash type memory of PIC16F84 program can theoretically be removed and re-programmed to up to 10 thousand times. This makes PIC16F84A suitable for program development, learning and application in life. In comparison, programmable logic controller (PLC) is usually used for wide range of tasks and more suited for industrial applications due to its various number of I/O. In addition, PLC is more expensive because it uses many chips. In this simple controlling project, it is sufficient to use microcontroller PIC16F84A.

Mapping pins for PIC microcontroller PIC16F84A is shown in figure 2. Further information regarding PIC16F84A may be referred to the data sheet MicrochipPIC16F84A. For the programming of this controller system, MicroBasic Pro v1.45 compiler software is used.

![Mapping pins PIC16F84A](image)

**Figure 2.** Mapping pins PIC16F84A.
4. Design Concept (Logic Flowchart)
Figure 3 represents the flowchart or process of the motorised bunker system, which shows the idea on how to operate the bunker door. This diagram represents overall movement, decision and selection of this automated door operation from start until end. Therefore, the programming development on this controller system should follow the logic of this flowchart.

![Flowchart of the motorized bunker system.](image)

5. Mechanism (Block diagram)
The block diagram of automated bunker door control system is shown in figure 4. This control system is programmed into a PIC micro-controller with five input data: forward button, reverse button, stop button, upper limit and lower limit instruction.

This input data is connected to the PIC Microcontroller programmed and link with two data output for the movement of reverse or forward of the bunker door. This information is communicated with the high torque reversible motor and it is connected to the pulley system. The pulley is attached to the existing steering wheel to move the door of the bunker. The type of reversible motor which will be used in this system is induction motor with capacity of 1 HP, 5.7 Ampere, 4 poles and 1430 r/min. The completed control board is shown in figure 5 and, the completed motorized automated bunker door is shown in figure 6.
6. Summary
The system has been developed, implemented and tested for its functionality. The result showed that the automated bunker door operated as required together with its safety implementation systems. In term of time and performance, by using this new automatic system, it only took less than one minute to open or close the door, as compared with previous manual system which took more than five minutes. This project also could be considered as cost effective because the whole controller system was locally designed and developed, including the programming and installation. The importance of the development of this automated bunker door is to increase effectiveness of time and work job so that utilization of manpower could be minimized.
7. References

[1] Ghazali A B, Mamat M R, Darmawan R, Chulan R M, Lee C. H, Leo K W and Taat M Z 2005 Development of electron beam machine at Nuclear Malaysia (Tech. and Appl. Accelerator Meeting VIII P3TM-BATAN Yogyakarta)

[2] Ahmad M A, Hashim S A, Ahmad A, Leo K W, Chulan R M, Dalim Y, Baijan A H, Zain M F and Ros R C 2017 The implementation of physical safety system in bunker of the electron beam accelerator AIP Conf. Proc. 1799 pp 030012

[3] Hashim S A, Jahar S, Muhamad A and Idris S 2011 Safety aspects of EPS-3000 electron beam machine (Nuclear Technical Convention Malaysia)

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