

Door Automation System for Smart Home Implementation

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Abstract— In this paper is presented the design and the prototype implementation of a pneumatic door automation system intended to be used for access control in smart homes. The structure of the developed application is realized around the PIC 16F877A microcontroller which operates together with a pneumatic actuator based on a double acting cylinder controlled through an air distributor with solenoid valve. In the basic mode, the door opening and closing actions can be initiated manually by the user, through password authentication. The main parameters of the system can be configured locally, but an in-depth diagnoses and reconfiguration can be performed only through the serial interface which ensure the communication between the main module of the system and an external PC. Compared with other similar systems, the proposed implementation solution allows a high operation speed and very good reliability due to the pneumatic actuation. In addition, the door automation module can be integrated in a centralized access control system dedicated to the smart homes that has all the appliances and other electricity based equipments connected into a local network.

Keywords— door automation, smart home, microcontroller, pneumatic control.

I. INTRODUCTION

The smart home concept based on the newest achievements in the field of artificial intelligence and network communications offers a very broad spectrum of applications which are expected to improve significantly the quality of life in the future. For example, the daily management of an increasing number of appliances including heating, ventilation, and air conditioning equipments (HVAC) that are often present in a modern house could represent a stressing but unavoidable task for ensuring the required level of safety and the certitude that all systems are in the proper state.

The smart home systems allow a continuous and real-time data exchange between the installed equipments and the user for obtaining highly advanced features for the buildings. Also, in recent times the concerns regarding the energy efficiency and human environmental impact represent other important driving factors that generate new developments in the field of automation systems for smart homes. In this context this paper describes a versatile door automation system dedicated for operation in smart homes access control equipments [1].

II. THE MODEL OF SMART HOME SYSTEMS

The smart home concept refers to a building that contains a particular type of automation system that is specifically implemented and dedicated for controlling the operation of the appliances, equipments and installations existent in that a residential environment (Fig. 1). The main functionalities and services ensured by a smart home consists in an enhanced security based on advanced access control and surveillance facilities, an efficient management of the energy consumption for an increased comfort but with a sustainable energetic performances and an extended and integrated support for the lifestyle and entertainment of the inhabitants. These kinds of systems integrate a variety of sensors and devices and usually use a communication network for internal and external information exchange. In practice can be distinguished two types of approaches for implementation of the home automation systems, based either on local or remote control. Both these implementation solutions have their specific advantages and drawbacks [2].

Designs based on local and centralized control are inherently more secure but suffers a certain lack of accessibility because of the missing features for remote connectivity. In contrast, home automation systems with open architectures that are based on various communication networks achieve an improved remote access. This important advantage came with the penalty of an increased vulnerability regarding the unauthorized access to the control functions of the system, but using appropriate encryption algorithms and other measures for security improvement this issue can be significantly alleviated.

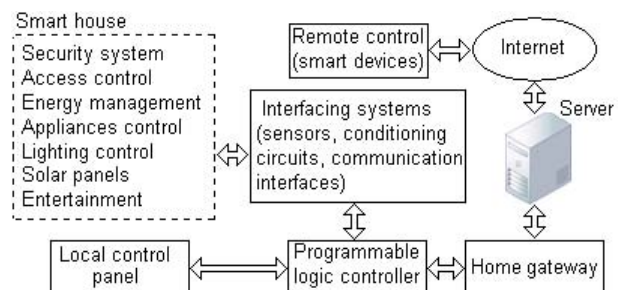


Fig. 1. The simplified model for the smart home concept implementation.

III. THE STRUCTURE OF THE DOOR AUTOMATION SYSTEM

The control module is implemented with PIC 16F877A general purpose microcontroller which realizes all the tasks required for the correct operation of the system. As can be observed in the Fig. 2 the pressurized air generated by the compressor is stored and directed to the proper port of the pneumatic actuator by the air distributor implemented with a dedicated solenoid valve. The position and implicitly the

opening degree of the door are continuously monitored through a resistive potentiometer acting as angular displacement sensor. For increased safety of operation and reliability, the control module is galvanic insulated, through optical coupler, from the solenoid valve of the pneumatic actuator [3]. The block diagram containing the most important elements that compose the hardware architecture of the proposed door automation system is depicted in Fig. 2.

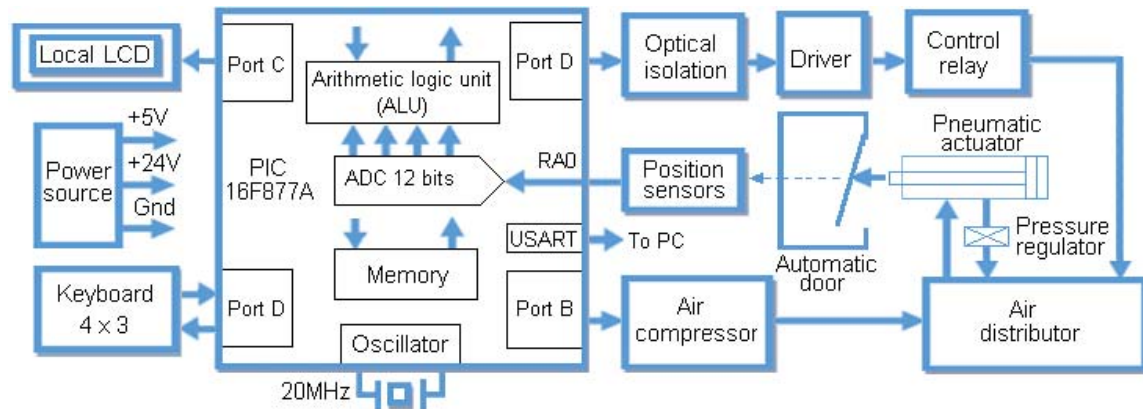


Fig. 2. The block diagram of the door automation system used for access control in smart homes.

IV. THE SOFTWARE APPLICATION

The general view of the state diagram for the software application that controls the operation of the PIC 16F877A microcontroller is presented in Fig. 3. The program was written, verified and compiled in assembler format using MikroC PRO development environment. The transfer of the assembler programming file into the flash memory of the microcontroller was realized using the MPLAB software tool which was chosen because it represents a easy to use but versatile solution that allows the development of embedded applications for common types of microcontrollers, especially PIC devices. As can be seen from the state diagram presented in Fig. 3 the software application begins with an initialization sequence followed by two successive readings of the values at the outputs of the position sensors and also the values from the all microcontroller's ports. In addition is activated the serial port (RS232) for establishing the communication with an external PC acting as server for an integrated smart home system. In this case it was used a proprietary LabVIEW application for managing the operation of the proposed door automation system. In normal conditions the system is in the idle mode waiting for a command from the user. In this state, on the local display of the control module is maintained visible the program interface and few representative parameters regarding the current situation of the system. The program interface contains a simplified menu that basically allows to the user to choose between two possibilities: configuration of the system or direct control of the position of the door. The access to the control menu is conditioned by the introduction of a valid password consisting in a string of four alphanumeric characters. The software application contains control procedures which continuously verify if the values introduced by the user are in the proper range and also if the required tasks are realized successfully.

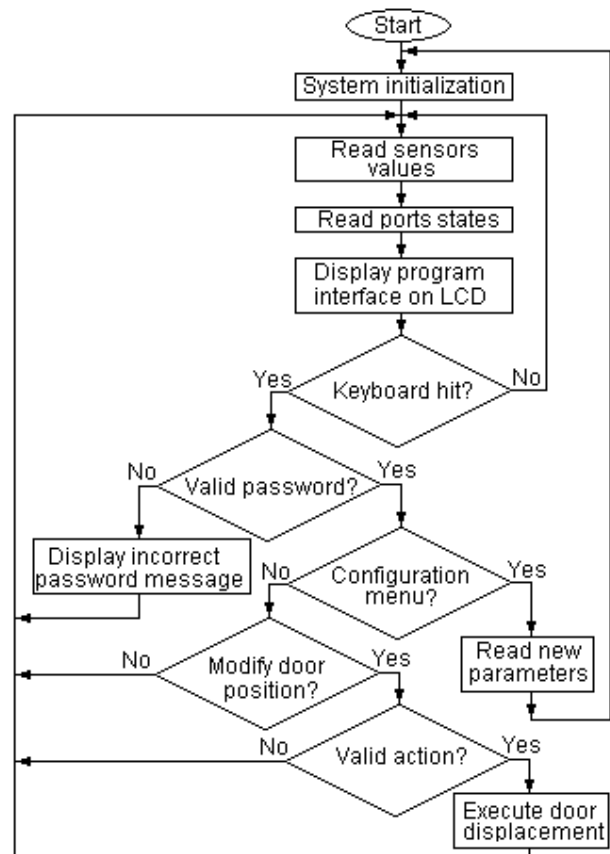


Fig. 3. The state diagram for the software application that controls the operation of the door automation system.

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