Microcontroller Based Thermal Enclosure for Electronic Boards Testing

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***Abstract**: In this paper is presented a new approach for implementing a versatile temperature control and monitoring system for thermal enclosures based on Peltier thermoelectric elements. The system is intended to be used for temperature testing of equipped or unequipped electronic printed circuit boards (PCB). These types of tests regarding thermal aging and endurance are very important for verifying the long term reliability of the PCBs because they must be designed for different categories of applications which impose certain operational time periods in various thermal conditions. The control module of the thermal enclosure described in this paper is realized with PIC16F877 microcontroller that communicates through serial interface with a dedicated software application running on PC. The functional parameters of the system can be monitored either on a local LCD or on PC's display. The testing procedures can be configured only from the software application. The power of the heating and cooling elements is around 36W allowing an effective temperature control in the range [-15 – 100] ˚C. Compared with classical implementations, the design using Peltier elements has the important advantage of been capable to operate within a wide range of temperatures, including negative values, which allows more accurate tests and a realistic characterization of the electronic boards.*

1. INTRODUCTION

The domain of accelerated temperature testing of electronic boards for accurate evaluation of the long term reliability represents an important research topic for the manufacturing industry. This problem becomes even more significant when are taken into consideration the applications that requires electronic systems capable to operate in extreme environmental conditions. For example, the long term reliability is of maximum concern in the design processes of medical electronic devices or military equipment.

Although, there is a large variety of software tools (FloTherm, PICLS, DynTIM etc.) capable to realize extended thermal analyses and simulations and even to make prediction regarding the airflow, temperature, and heat transfer in components, boards, and in complete systems, the practical temperature testing using an dedicated installations remain the most trustworthy and accurate method for this kind of characterization.

For these reasons this paper approaches the problem of implementation of a versatile temperature testing system capable to perform realistic investigations regarding the thermal aging and thermal endurance of electronic PCBs [1], [2].

2. THE STRUCTURE OF SYSTEM

In the Fig. 1 is presented the simplified structure of the thermal enclosure dedicated for temperature testing of electronic boards. The main component of the system is the PIC16F877 microcontroller that controls the operation of the entire system. The control module of the thermal enclosure is also permanently in communication mode with the software application that runs on the PC.

For achieving a better accuracy of the measurements, the temperature in the thermal enclosure is permanently monitored with two LM35 sensors placed in distinct locations, usually the top and bottom walls of the thermal chamber.

Based on the information that are periodically read from the both sensors the microcontroller calculates the average temperature in the thermal enclosure and use this value for the execution of the testing algorithm. The volume of the thermal enclosure was established to approximately 1 cubic decimeter which is sufficient for testing medium electronic boards. This limitation was imposed by the power of the heating and cooling elements that in correlation with the volume of the thermal enclosure have a direct influence on the response time of the system which must be maintained at reasonable values for performing realistic tests [3].

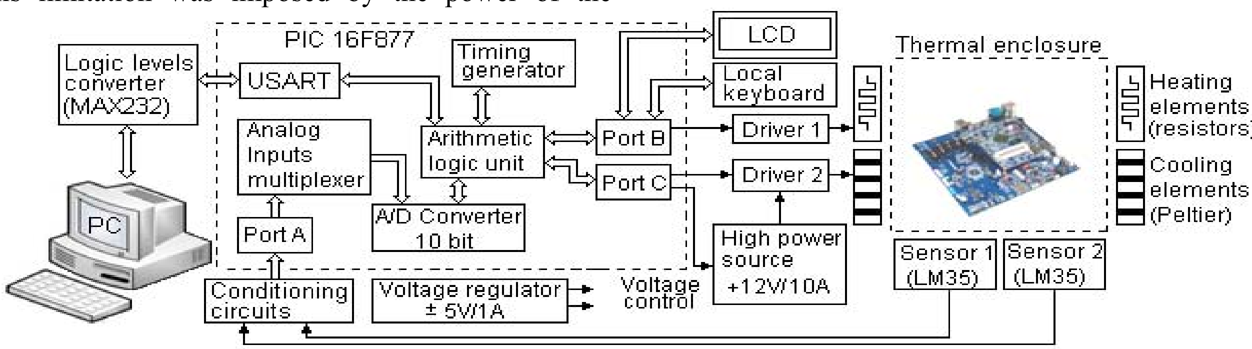

Fig. 1. The structure of the system used for temperature testing of electronic boards

3. THE SOFTWARE APPLICATION FOR THERMAL ENCLOSURE CONTROL

The proposed system contains two main software components, one for the PIC16F877 microcontroller and the second for the PC. The application for microcontroller was written in assembler language and was programmed into the internal flash memory using MPLAB tool. The software application for the PC is realized in LabVIEW graphical programming environment and ensures supervisory functions for the thermal enclosure. A picture containing the front panel of the LabVIEW application is presented in Fig. 5. As can be observed from this image the application contains two main parts: a control section and a real time temperature display section. In the control section the user can configure the temperature limits, the hysteresis, and the acquisition speed of the sensor's signals. The software algorithm that controls the temperature in the system allows two modes of operations: automatic, with a predefined pattern of variation and manual operation respectively. The temperature variation patterns can be configured by the user in plain text files which then are loaded in the proprietary LabVIEW software application that controls the operation of the external module connected to the PC through the RS232 serial interface. The easy editable patterns represent a valuable characteristic of the proposed design because it ensures the required flexibility of the performed tests. Also, manual operation is desirable when quick tests are necessary to be performed. In Fig. 2 is presented a general state diagram of the software module responsible with the automate temperature control. As can be observed from this figure the temperature is controlled considering a hysteresis of 0,5 ˚C, but this parameter is available for user configuration, using dedicated knob existent on the front panel of the LabVIEW application (Fig. 5).

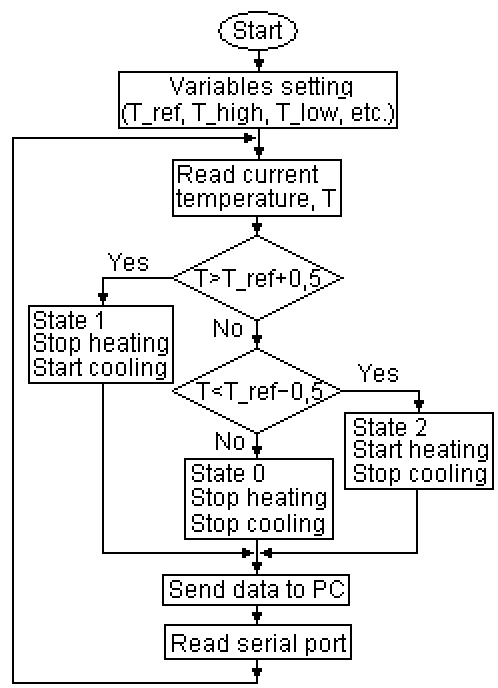

Fig. 2. The simplified state diagram for the software module responsible with the automate temperature control.

4. IMPLEMENTATION AND RESULTS

The high levels of current that are required by the operation of the Peltier elements and the heating resistors are generated with a 12 V power source managed by the PIC16F877 microcontroller. The heating and cooling elements are controlled by pulse-width modulated signals having different frequencies of approximately 1 kHz and 50 mHz, respectively.

In Fig. 3 is illustrated the prototype of the proposed thermal enclosure. Also, the hardware structure of the control system is presented in schematic from Fig. 4. As temperature sensors were used LM 35 circuits that are characterized by a sensibility of 10mV/˚C and a relatively large measurement domain in the range [-55 - 150] ˚C. This component was the limiting factor for the precision of the system [4].

The MAX 232 circuit ensures the logic level conversion for interconnecting the serial port of the microcontroller to the USART circuit of the PC. The external control module is in permanent communication with the LabVIEW application that runs on PC. For local configurations and for menu scroll on local display are available four buttons named Up, Down, Ok, and Clear. The heating and cooling elements are supplied with energy through dedicated relays, only when the testing algorithm is running. The internal operation of the Peltier elements imposed a control scheme based on reduced frequency PWM signals that can be applied through relays [5].

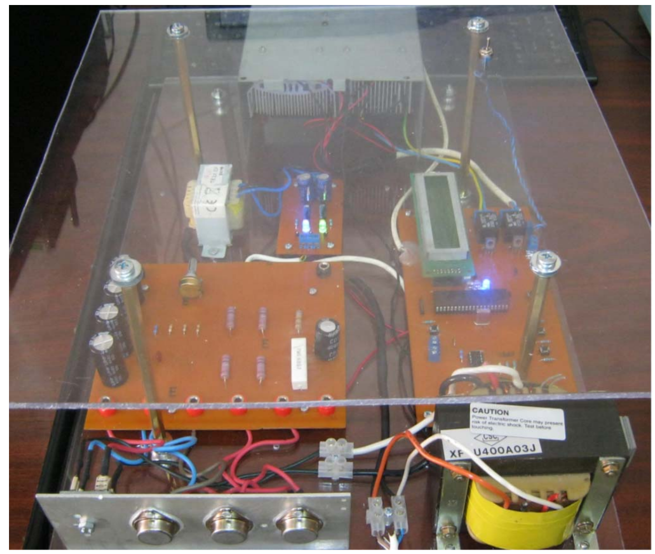

Fig. 3. The implementation of the proposed thermal enclosure used for temperature testing of electronic modules.

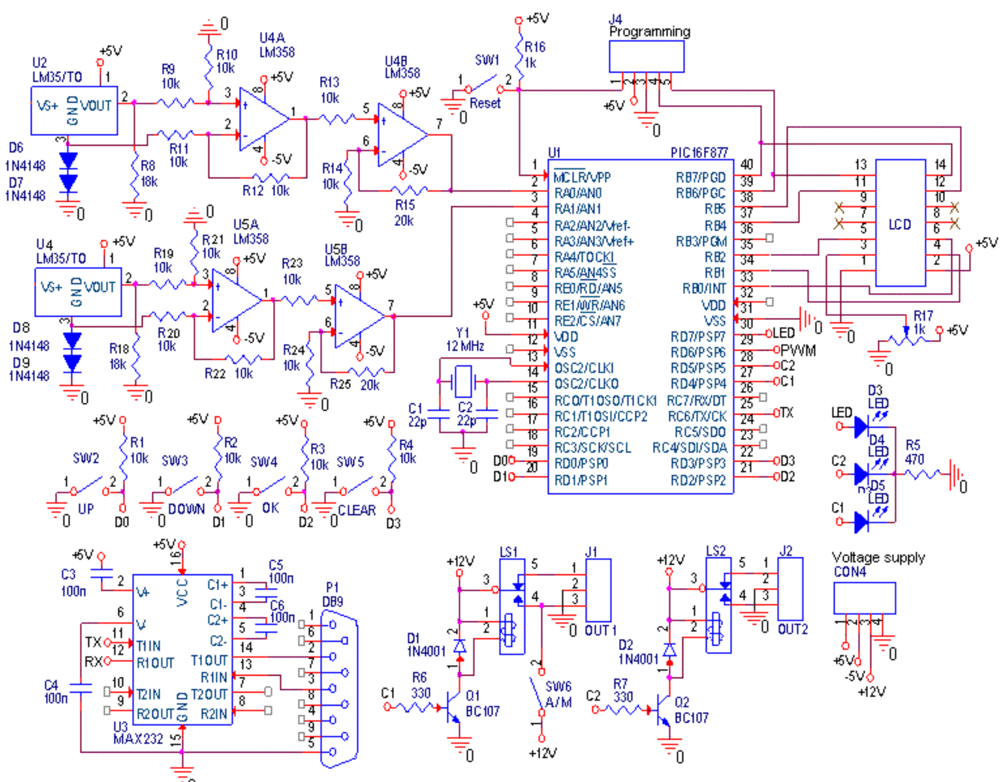

Fig. 4. The electronic schematic of the control module for the thermal enclosure based on Peltier elements.

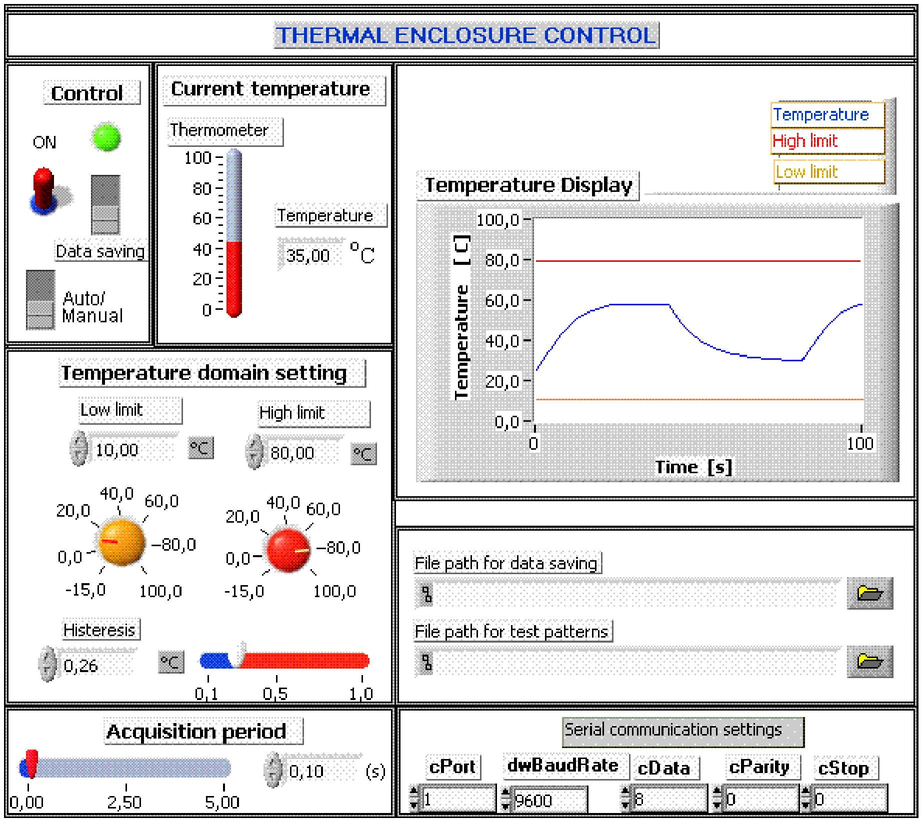

Fig. 5. The front panel of the LabVIEW application that controls the proposed thermal enclosure used for temperature testing of electronic modules.

5. CONCLUSIONS

The accelerated temperature testing of electronic boards is important in applications that requires high reliability such as military equipments, medical electronic devices etc.

Due to the design that use Peltier elements, the microcontroller based thermal enclosure presented in this paper ensure a wide temperature range, including negative values, which allows more accurate tests of the electronic boards.

The easy editable patterns represent a valuable characteristic of the proposed design because it ensures the required flexibility of the performed tests.

The compact design of the proposed system, based on a versatile microcontroller, doubled by the attractiveness of the LabVIEW interface makes this thermal enclosure a valuable tool for thermal testing of electronic modules.

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