

Temperature Control of a Hot Plate Using Microcontroller-Based PWM Technique

Tabinder Akter¹

¹ University of Dhaka

Received: 12 February 2012 Accepted: 5 March 2012 Published: 15 March 2012

Abstract

The temperature of a hotplate used for prebaking, post baking, dehydration baking etc. changes with time. But, in baking purpose the temperature should remain constant. This work concerned with the designing a new and cost-effective microcontroller based PWM temperature controller to control the temperature of a hot plate. PWM controller has been selected because it has faster and accurate response than the conventional on-off controller. Here, the microcontroller senses the zero crossing of the line voltage and generates a pulse for every half-cycle. The width of the pulse is adjusted to change the firing angle of a TRIAC. The TRIAC is interfaced with the microcontroller circuit using an opto-coupler. The temperature of the hot plate can be increased or decreased using two push-button switches. The preset temperature will be saved in EPROM of microcontroller and displayed on an LCD display. The temperature of the hot plate is sensed by a thermocouple and feedback to the microcontroller. The microcontroller keeps the temperature constant by changing the firing angle of the TRIAC. The system has been constructed and tested successfully.

Index terms— Microcontroller, PWM controller, TRIAC, EPROM, Zero-crossing, Temperature Control.

A Abstract -The temperature of a hotplate used for prebaking, post baking, dehydration baking etc. changes with time. But, in baking purpose the temperature should remain constant. This work concerned with the designing a new and costeffective microcontroller based PWM temperature controller to control the temperature of a hot plate. PWM controller has been selected because it has faster and accurate response than the conventional on-off controller. Here, the microcontroller senses the zero crossing of the line voltage and generates a pulse for every half-cycle. The width of the pulse is adjusted to change the firing angle of a TRIAC. The TRIAC is interfaced with the microcontroller circuit using an opto-coupler. The temperature of the hot plate can be increased or decreased using two push-button switches. The preset temperature will be saved in EPROM of microcontroller and displayed on an LCD display. The temperature of the hot plate is sensed by a thermocouple and feedback to the microcontroller. The microcontroller keeps the temperature constant by changing the firing angle of the TRIAC. The system has been constructed and tested successfully.

1 Introduction

hotolithography is very important in fabrication process [1]. During this process it is necessary to bake substances at different constant temperatures [2][3][4]. For baking purpose a hotplate is needed, whose temperature is not normally fixed [5]. Many manufacturers all over the world are supplying electronic equipment to control temperature of a hotplate but those equipments are very costly [6]. This work is intended to design low cost equipment with locally available materials.

The temperature of hotplate increases linearly and can't fix any temperature for a certain period of time. It is needed to fix the temperature of hotplate for a certain period of time. The work is intended to pre-bake or post-bake or hard-bake the Photo-resists spun onto the semiconductor wafers [1].

7 CONCLUSION

43 For a particular application of pre-baking the Positive Photo-resist spun onto 400-450 micron thick Silicon
44 wafer of about 1 cm x 2 cm. A temperature of 100 C is needed to be fixed for 10 minutes or 30 minutes [7][8][9].

45 The research conducted here is a combined hardware and software design process with an objective to develop
46 a versatile control system. The work is divided in two sections: hardware section and software section.

47 2 II.

48 3 Block Diagram of the System

49 The block diagram of the system is shown in figure 1. It consists of control unit, feedback unit, temperature
50 heater, power control unit, PWM control, 220V line voltage, zero crossing detector. The temperature of hotplate
51 is displayed by an LCD which is connected with a 16F877 microcontroller. Hotplate converts temperature into
52 voltage by a thermocouple. A high gained amplifier is used in the ADC input of the microcontroller. The hotplate
53 temperature is feedback by this amplifier section. This section is important because the temperature sensed by
54 a thermocouple is so small and need to amplify. The The plate temperature is sensed by a thermocouple and
55 amplified by an instrumentation amplifier and applied to the microcontroller. The input voltage is then converted
56 to digital signal by the ADC of the PIC16F877A and compared to the data stored in the EEPROM of the IC
57 [11][12][13]. The LCD is connected with one of the output port of the microcontroller [14]. Switches have been
58 connected with two input pins of an input port. The port was so programmed that it scans to check if the switch
59 was pressed or not. By pressing the switches the set value of the temperature can be increased or decreased.

60 PIC16F877A have total 28 pins as shown in figure ?? . Pin-1 (/VPP) of the IC is connected with VCC through
61 a resistance [14]. This pin is the master reset pin. When the pin is connected with ground, the current program
62 is reset and starts executing from the beginning of the program when again connected with V .

63 Figure ?? 3 : Control Unit.

64 4 c) Power Control Unit

65 To isolate the microcontroller based control system from the high power side an opto-coupler has been used to
66 fire the TRIAC [14]. The main type of optocoupler found in the local market is the type having an output DIAC
67 or bilateral switch, and intended for use in driving a TRIAC or SCR. Examples of these are the MOC3020 and
68 MOC3021. Here the output side of the opto-coupler is designed to be connected directly into the triggering
69 circuit of the TRIAC.

70 As expected, the output of the DIAC is connected into the TRIAC gate triggering circuit in much the same
71 way as a discrete DIAC. We need a filter/delay circuit before the DIAC (R1-2 and C1) and the usual snubber
72 circuit across the TRIAC (Rs,Cs) to ensure correct triggering with inductive loads. Normally also need at least
73 an RFI suppressor choke LRFI as well, plus a suitable capacitor across the load [14]. In this system, the line
74 voltage has been lowered down by a step-down transformer and the sinewave is directly given into a comparator
75 of the microcontroller [15] which acts as a zero crossing detector. The comparator compares this signal with zero
76 reference voltage. Whenever a transition is produced at the output of the comparator, the microcontroller begins
77 a pulse whose width depends on the preset value of the temperature.

78 5 Software Development

79 The system is fully controlled by a program. The program has been written using FlowCode software. First, we
80 set a temperature as shown in figure 6. Here, hotplate temperature is controlled using duty cycle. For greater
81 temperature it increases its duty cycle and for lower temperature it decreases its duty cycle for controlling the
82 temperature.

83 V.

84 Results & Discussion a) Temperature Reading of a Hotplate Our system is now ready to fix the temperature.
85 We set our circuitry with the hotplate and control its temperature [3]. Our designed program is nice and work
86 properly. The observed data of a hotplate for a set value of temperature is given below: Data Table ?? : ??).

87 It is evident that the temperature was increased from 15 C to 70 C for 5 minutes and after 5 minutes the
88 temperature of the hotplate is fixed.

89 6 VI.

90 7 Conclusion

91 The results of the performance study reveal that the developed system works properly with an excellent accuracy.
92 One target of the system is to keep temperature of a device constant. A microcontroller chip 16F877A is used
93 and it has a 256 bytes data EEPROM memory. So, this system can store up to 128 data. The LCD used in this
94 system can display the stored data in EEPROM when the specific switch is pressed. Thus we can collect and
95 analyze the data when necessary.

96 The other target of the system is to provide economic benefit to its users. Cheap and available components are
97 used to design the system. The size of (For Preset Temp. 70 C) 0 0 0 the system is small. Two ways -power and
98 small size make the device portable. So, it can be easily carried and implemented anywhere. The efficiency of

99 the system is satisfactory. The A/D converter module has a high resolution and thus the accuracy of the system is nearly perfect. ¹



Figure 1: Figure 1 :



Figure 2: P



Figure 3: Figure 2 :



4

Figure 4: Figure. 4 :



5

Figure 5: Figure. 5 :

6

Figure 6: Figure. 6 :



7

Figure 7: Figure. 7 :

8

Figure 8: TemperatureFigure. 8 :

-
- 101 [Winpicprog (2009)] , Winpicprog . http://www.winpicprog.co.uk/pic_tutorial.htm November 12 ,
102 2009. November 2009.
- 103 [Boylestad and Nashelsky (2003)] Robert L Boylestad , Louis Nashelsky . http://www.mikroelektronika.co.yu/english/product/books/PICbook/0_Uvod.htm *Electronic Devices and Circuit Theory*, (India)
104 2003. November 12. 2009. November, 2009. Prentice Hall. 15. (7th Edition)
105
- 106 [Enderlein et al. ()] Rolf Enderlein , J Norman , Horing . *Fundamentals of semiconductor physics and devices*,
107 (Singapore) 1997. World Scientific Publishing Co Pte Ltd. (1st edition)
- 108 [Gary and Mcguire ()] F Gary , Mcguire . *Semiconductor Materials and Process Technology Handbook*, (India)
109 2008. Jaico Publishing House. (6th edition)
- 110 [Tay et al. (2004)] ‘Integrated bake/chill module with in situ temperature measurement for photoresist process-
111 ing, Semiconductor Manufacturing’. A Tay , W K Ho , A P Loh , K W Lim , W W Tan , C D Schaper .
112 *IEEE Transactions* May 2004. (2) p. .
- 113 [Lim et al.] ‘Integrated in-line temperature measurement system for silicon wafer semiconductor manufacturing’.
114 K W Lim , J Luo , J Gu , Y P Poh , W W Tan , A P Loh . IECON '99. *The 25th Annual Conference of the*
115 *IEEE Industrial Society*, p. .
- 116 [Bates ()] *Interfacing PIC Microcontrollers Embedded Design by Interactive Simulation*, Martin Bates . 2006.
117 Great Britain: Elsevier. (1st edition)
- 118 [Iovine ()] J Iovine . *PIC Microcontroller Project Book*, (USA) 2000. McGraw-Hill. (1st edition)
- 119 [Cole (2009)] *Parmer data sheet for hot plates. 625 East Bunker Court Vernon Hills, IL 60061 USA*, Cole .
120 <http://datasheets.globalspec.com/ds/2679/ColeParmer> November, 2009.
- 121 [Photoresist Coating Hood” Northwestern University Micro/Nano Fabrication Facility (NUFAB)] *Photoresist*
122 *Coating Hood” Northwestern University Micro/Nano Fabrication Facility (NUFAB)*,
- 123 [Ben et al. ()] *Solid State Electronic Devices*, G Ben , Sanjay Streetman , Banarjee . 2001. India: Prentice-Hall
124 India. (5th Edition)
- 125 [Ibrahim] ‘Teaching digital contrl using a low cost microcontroller-based temperature control kit’. D Ibrahim .
126 *International Journal of Electrical Engineering Education* Department of computer engineering, Near East
127 University
- 128 [Woo Sik Yoo et al.] ‘The effect of pulse width modulation (PWM) frequency on the reliability of thermoelectric
129 modules’. Taro Woo Sik Yoo , Toshiyuki Yamazaki , Uchino . *TE technology, Inc. 1590 keani drive*, Michael
130 J Nagy, Steven J Roman (ed.) (San Jose, CA 95112 USA; Hitachinaka, Ibaraki; Traverse city, Michigan)
131 *Trecenti Technologies, Inc.751 Horiguchi. p. . (Low Temperature Annealing System for 300mm Wafers)