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Digital Clock with Speech Recognition

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ABSTRACT

One of the functions of a digital clock is to wake us from sleep, in order to perform the activities as scheduled. Technological developments allow the incorporation of digital clock function with voice recognition, making it easier for us to do as to turn off the alarm without having to press a button, asking what time without having to view the display, and so forth. From these points of view, the idea to design and to implement a "Digital Clock with Speech Recognition" came up. This experiment concentrates in designing the hardware and the software that will work as an integration system of circuit that has the digital clock function. The circuit also has other function which is the speech recognition. Through this function, the user of the circuit will be able to record his or her voice in the form of short words. After the recording, the user can start to order the circuit to recognize his or hervoice. Finally, both digital clock and speech recognition functions are combined to work together, therefore when there is a voice recognized, then the speech recognition circuit will send a digital signal to the digital clock circuit to be processed as an input signal to operate certain digital clock function.

Keywords: *digital clock, speech recognition, microcontroller ATmega8535*

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I. Introduction

In this globalization era, many people are workaholic that they get used to be in the hectic situation. This situation surely would make them very tired. It means that every time they take a rest late at night after coming back from their job, in the morning they might not be able to wake up on time to continue the job. It happens because our bodies could not wake up on time naturally in the exhausted condition; therefore we need an alarm to help us wakening our bodies from a night sleep. The alarm is usually available as one of the main programs in a device called Digital Clock.

As we know, the globalization era must be in line with the rapid technology development. This phenomenon results in the behavior of people that they tend to find the instant way in fulfilling their needs. Many of them become familiar to utilize the high technology facility in their daily life. Recently, people would rather perform their regular tasks with Speech Recognition technology instead of pressing buttons. For example, people would probably want to activate the lights in the apartments or to answer the phone call through a simple speech command. From these points of view, the idea to design and to implement a "Digital Clock with Speech Recognition" came up.

This experiment concentrates in designing the hardware and the software that will work as an integration system of circuit that has **five functions as a digital clock** such as ***setting time (hour, minute, date, month, year, and day of the week)***, ***setting the hour mode (12-HR mode or 24-HR mode)***, ***setting alarm***, ***putting the alarm on the standby mode***, and ***turning on/off the light of LCD display***.

The circuit also has other function which is the **speech recognition**. Through this function, the user of the circuit will be able to ***record*** his or her ***voice*** in the form of short words. After the recording, the user can start to order the circuit to ***recognize*** his or her ***voice***.

Both digital clock and speech recognition functions are combined to work together. Therefore, when there is a voice recognized, then the speech recognition circuit will send a digital signal to the digital clock circuit to be processed as an input signal to operate certain digital clock function.

The objective of this experiment is to provide a convenience for regular activity that many people have to do every night; which is taking their digital clocks to make sure that the alarm has already been put on the standby mode. The digital clock designed in this experiment features speech recognition as the innovative function of the clock. With only simple speech commands, the digital clock will be able to put the alarm on or off the standby mode and also to run the other clock function as the user desires.

II. Methods

In this experiment, the author constructs the Digital Clock with Speech Recognition by using the microcontroller ATmega8535. The block diagram of this experiment is shown in Fig. 1.

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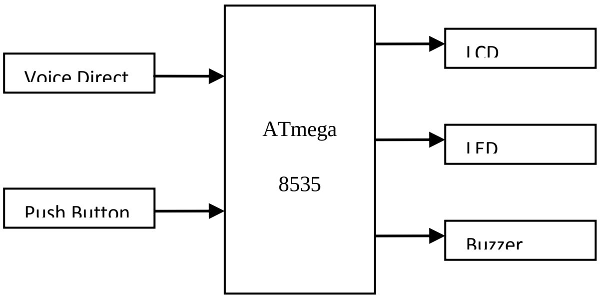

Fig. 1. Block Diagram

The block diagram describes the main circuit components which are used. Voice Direct II and push button perform as the inputs of the system, whereas LCD, LED, and buzzer perform as the outputs of the system. The microcontroller ATmega8535 performs as the processor of the digital signals sent from the system inputs to produce the digital signals for activating the system outputs.

1) Microcontroller ATmega8535

Fig. 2.Microcontroller ATmega8535

Microcontroller ATmega8535 is the most important component of the circuit. It is because the microcontroller organizes every part of the system. The ATmega8535 is a low-power, high-performance of AVR® 8-bit microcontroller with 8 kilobytes of In-System Programmable Flash supported by Read-While-Write capabilities. The device is manufactured using Atmel's high-density nonvolatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core.The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation [MIC10].

The ATmega8535 has 40 pins which have different electronic roles. Some of those pins are connected to the system input and output components. The other pins are attached to the voltage source (Vcc), ground, and crystal oscillator (speed grade used: 8 MHz) as an inverting amplifier which can be configured for use as an On-chip Oscillator. Here are the descriptions of the pin configurations:

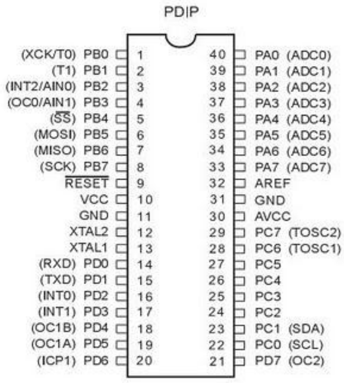

Fig. 3.ATmega8535 Pin Configurations

a. **Vcc**: Digital supply voltage(operating voltage: 5V).

b. **GND**: Common ground of the circuit.

c. **Port A (PA7..PA0)**, **Port B (PB7..PB0)**, **Port C (PC7..PC0)**, **Port D (PD7..PD0)**: Port A, Port B, Port C, and Port D are the 8-bit bi-directional I/O ports with internal pull-up resistors (selected for each bit). Those ports' output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, those ports' pins that are externally pulled low will source current if the pull-up resistors are activated. These pins are tri-stated when a reset condition becomes active, even if the clock is not running.

d. **RESET**: Reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running.

e. **XTAL1**: Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

f. **XTAL2**: Output from the inverting oscillator amplifier.

g. **AVCC**: AVCC is the supply voltage pin for Port A and the A/D converter. It should be externally connected to Vcc, even if the ADC is not used. If the ADC is used, it should be connected to Vcc through a low-pass filter.

h. **AREF**: AREF is the analog reference pin for the A/D converter.

2) Voice Direct II

Voice Direct II is aimed at being a simple, entry-level kit for electrical engineers and developers looking at adding speech technologies to their products or experiments. The Voice Direct II feature set includes four speech recognition techniques (edge-trigger: single recognition, single-trigger: continuous listening, multiple-trigger: continuous listening, and single-trigger: word-spotting), recognizes up to 15 words or phrases (broken into 1, 2 or 3 sets) with phase recognition up to 2.5 seconds, and claims over 99% accuracy with proper design. The kit itself shown in Fig. 4 comes with the Voice Direct test platform motherboard supported by the built-in speaker and microphone, detachable Voice Direct II module, and a Quick Start guide.

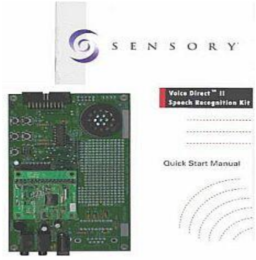

Fig. 4. Sensory Voice Direct II Toolkit

Since the Voice Direct II uses the same technology as other Sensory products, the performance is excellent. Its chip can compensate for uniform background noise as well as a variety of microphones and distances. Since the recognition is purely speaker-dependent, training is quick and simple (repeat the training word twice) and recognition is extremely fast and very accurate. Falsely recognized words were few and far between, but 'no match' errors were a little more common. Nevertheless, even in sub-optimal operating conditions, the accuracy is definitely around 80-90% [SEN10].

In this experiment, the author uses Voice Direct II to ***recognize*** voices that have been ***recorded*** by the user to activate **two digital clock functions**; the functions are ***putting the alarm on the standby mode*** and ***turning on/off the light of LCD display***. For applying this kit to the experiment, the author utilizes **connector (J1) of Voice Direct II motherboard pin assignments** which are shown in Table 1.

Table 1. Connector (J1) Pin Assignments

Connector	Pin #	Name	Description	I/O
J1	01	+3.3V	3.3 Volt (+) power supply connection	I
J1	02	+3.3V	3.3 Volt (+) power supply connection	I
J1	03	OUT1(P0.0)	Output 1 or 9 (Active high)	O
J1	04	-TRAIN(P1.0)	Start SD Training / Configure Training/Recognition Sensitivity (see below)	I
J1	05	OUT2(P0.1)	Output 2 or 10 (Active high)	O
J1	06	-RECOG(P1.1)	Start Recognition / Configure Microphone Sensitivity (see below)	I
J1	07	OUT3(P0.2)	Output 3 or 11 (Active high)	O
J1	08	-TRIG TRAIN(P1.2)	Start Trigger Word Training (SCL, MCL, SWS modes only) / Configure CL Performance (see below)	I
J1	09	OUT4(P0.3)	Output 4 or 12 (Active high)	O
J1	10	OUT6(P1.3)	Output 6 or 14 (Active high)	O
J1	11	OUT5(P0.4)	Output 5 or 13 (Active high)	O
J1	12	OUT7(P1.4)	Output 7 or 15 (Active high)	O
J1	13	-	Not Used – Leave Open	-
J1	14	OUT8(P1.5)	Output 8 (Active high)	O
J1	15	-	Not Used – Leave Open	-
J1	16	MODE1(P1.6)	Mode Selection Pin 1	I
J1	17	TALK(P0.7)	Output Active High When Voice Direct™ II is Listening For User Speech	O
J1	18	MODE2(P1.7)	Mode Selection Pin 2	I
J1	19	GND	Ground connection	I
J1	20	GND	Ground connection	I

From the list of pins above, there are **two important modes of Voice Direct II** which are ***training mode*** and ***recognition mode***[VOI10]. Here is the explanation of both modes:

a) Training Mode

Previously, it was discussed that Voice Direct II feature set includes four speech recognition techniques. However, at this experiment, the author applies the edge-trigger: single recognition technique. At this technique or mode, Voice Direct II module should be configured for SD mode (**Pin # 16 – MODE1** and **Pin # 18 – MODE2** must be open circuited). When **Pin # 04** (**-TRAIN**) is pulled to the ground for at least 100 ms (by pressing the related push button), training will begin. Voice Direct II will prompt "Say word x" (where x corresponds to the word to be trained).

A trained word or phrase must be no longer than 2.5 seconds and may not contain silences longer than 0.5 seconds. For example, the name "John Smith" would be an acceptable phrase as long as the two words are not separated by a large pause. Training terminates when no word is spoken in response to a prompt, when any push button is pressed a second time during training, when three errors have occurred during training, or after all 15 words have been trained.

Bringing **Pin # 04** low at a later time resumes training. New words are added to the end of the set already recorded. New words may be added to the set at any time, up to a maximum of 15 words. Individual words from the set may not be deleted or overwritten, but the entire set can be erased (by pulling **Pin # 06** (**-RECOG**) and **Pin # 04** together to the ground). The user says the first word to be trained, then Voice Direct II prompts again with "Repeat".

The user repeats the word, and Voice Direct II will return "Accepted" if the word has been successfully trained. Otherwise, it will indicate the cause of training error. If an error occurs during training, then the error will be spoken "Spoke too soon", "Please talk louder", etc. The user will get three attempts to train each word before Voice Direct II exits training mode, and says "Training complete".

The user can exit training at any time by bringing **Pin # 04** or **Pin # 06** low, by not responding to a "Say word x" or "Repeat" prompt, or when all 15 words have been trained. However, **in this experiment, *there are only two words used to operate two digital clock functions***.

b) Recognition Mode

When **Pin # 06** (**-RECOG**) is pulled to the ground for at least 100 ms, recognition will begin. Voice Direct II will prompt "Say a word". If the response is not recognized, Voice Direct II will say "Word not recognized" and exit recognition mode. If the spoken word matches a stored template, one or two of 8 output pins are activated (pulled high for approximately one second) and a voice message indicates the matching response. If the set contains 8 or fewer elements, these pins may be used to control actions directly. If the set contains more than 8 elements, decoding is necessary. The logical format of the outputs is shown in Table 2.

Table 2.Logical Format of Recog. Mode Outputs

Recognition Word	OUT1	OUT2	OUT3	OUT4	OUT5	OUT6	OUT7	OUT8
Command Word 01	A							
Command Word 02		A						
Command Word 03			A					
Command Word 04				A				
Command Word 05					A			
Command Word 06						A		
Command Word 07							A	
Command Word 08								A
Command Word 09	A							A
Command Word 10		A						A
Command Word 11			A					A
Command Word 12				A				A
Command Word 13					A			A
Command Word 14						A		A
Command Word 15							A	A

Note: "A" indicates that the outputs are "Active-high".

If an error occurs during recognition (except for “Word not recognized”), then the error will be spoken “Spoke too soon”, “Please talk louder”, etc. If the spoken word is not recognized for any reason, none of the pins are activated and an appropriate voice message, “Word not recognized”, is synthesized.

For each command word, Voice Direct II monitors the background noise level. Best results will be obtained in a relatively quiet location. Warnings may also appear if the word is spoken too softly, too loudly, or too quickly after the prompt.

3) Push Button

A push button is a simple switch mechanism for controlling some aspect of a machine or a process. Buttons are typically made out of hard material, usually plastic or metal. The surface is usually flat or shaped to accommodate the human finger or hand, so as to be easily depressed or pushed. Buttons are most often biased switches, though even many un-biased buttons (due to their physical nature) require a spring to return to their un-pushed state. Different people use different terms for the "pushing" of the button, such as press, depress, mash, and punch [PUS10].

At this experiment, the author uses **eight non-polar mini push buttons** as the system inputs. Beside it is effective to be used; mini push button is also cheap and easy to be found. The physical appearance of the button is shown in Fig. 5.

Fig. 5. Mini Push Button

According to the eight non-polar mini push buttons used in the experiment, here is the description of these buttons’ roles in the circuit:

a. **Button 1** →connected directly to **PA0 of ATmega8535** to send logic 0 or not to send any logic to the microcontroller related to ***setting time (hour, minute, date, month, year, and day of the week)*** function of the digital clock.

b. **Button 2** →connected directly to **PA1 of ATmega8535** to send logic 0 or not to send any logic to the microcontroller related to ***setting alarm and incrementing time*** functions of the digital clock.

c. **Button 3** →connected directly to **PA2 of ATmega8535** to send logic 0 or not to send any logic to the microcontroller related to ***decrementing time*** functions of the digital clock.

d. **Button 4** →connected directly to **PA3 of ATmega8535** to send logic 0 or not to send any logic to the microcontroller related to ***setting the hour mode (12-HR mode or 24-HR mode)***function of the digital clock.

e. **Button 5** →connected directly to **PA4 of ATmega8535** to send logic 0 or not to send any logic to the microcontroller related to ***putting the alarm on the standby mode*** function of the digital clock.

f. **Button 6** →connected directly to **PA5 of ATmega8535** to send logic 0 or not to send any logic to the microcontroller related to ***turning on/off the light of LCD display*** function of the digital clock.

g. **Button 7** →connected directly to **Pin # 04 connector (J1) Voice Direct II** that will allow this pin to be pulled to the ground to turn on the ***training mode*** to record the user’s voice.

h. **Button 8** →connected directly to **Pin # 06 connector (J1) Voice Direct II** that will allow this pin to be pulled to the ground to turn on the ***recognition mode*** to recognize the user’s voice.

4) Liquid Crystal Display

Liquid Crystal Display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly. LCDs therefore need a light source and are classified as "passive" displays. Some types can use ambient light such as sunlight or room lighting. There are many types of LCDs that are designed for both special and general uses. They can be optimized for static text, detailed still images, or dynamic, fast-changing, video content [LIQ10]. At this experiment, the author uses the **LCD 16x2**. It means the LCD has 16 characters per line by 2 lines with the total of 32 characters. This LCD is supported with **LED backlight**, thus the user is able to **turn on/off the light of LCD display**. The appearance of LCD 16x2 is shown in Fig. 6, while its pin configurations are shown in Fig. 7.

Fig. 6. LCD 16x2

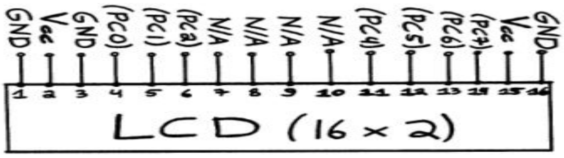

Fig. 7. LCD Pin Configurations

For this experiment, the author connects **Pin # 2 of LCD 16x2** to the supply voltage (Vcc: 5 V). On the other hand, the author connects **Pin # 1**, **Pin # 3**, and **Pin # 16 of LCD 16x2** to the circuit common ground. For **Pin # 7** to **Pin # 10 of LCD 16x2**, the author lets them to be open circuited. To display all digital clock functions, there are **seven pins of LCD 16x2** attached to the **Port C of ATmega8535** such as **Pin # 4 → PC0**, **Pin # 5 → PC1**, **Pin # 6 → PC2**, **Pin # 11 → PC4**, **Pin # 12 → PC5**, **Pin # 13 → PC6**, and **Pin # 14 → PC7**. However, **Pin # 15 of LCD 16x2** is attached to **PD5 of ATmega8535** by using a ***transistor inverter (NOT gate) circuit***, *as the supporting component*, to receive logic 1/0 from the microcontroller related to ***turning on/off the light of LCD display*** function of the digital clock.

5) Light Emitting Diode

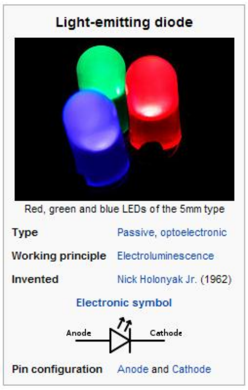

Fig. 8. Description of LED

Light Emitting Diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. Firstly introduced as a practical electronic component, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness. LEDs present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved robustness, smaller size, faster switching, and greater durability and reliability. They enjoy use in applications as diverse as replacements for traditional light sources in aviation lighting, automotive lighting (particularly indicators) and in traffic signals[LIG10]. At this experiment, the author uses **five types of LED** which are:

a. **Red LED**. This red light emitting diode indicates that the power supply has already close circuited, thus it could generate Vcc for the circuit.

b. **Yellow LED**. This yellow light emitting diode indicates that the circuit is on the **standby mode** not to recognize any voice from the user. (This LED is connected to **PD2 of Atmega8535** by using 25Ω resistor in series to receive logic 1/0 from the microcontroller related to **standby mode** of the circuit.)

c. **Green LED**. This green light emitting diode indicates that the circuit is on the **listening mode** to recognize a voice from the user for activating either ***putting the alarm on the standby mode*** or ***turning on/off the light of LCD display*** function of the digital clock. (This LED is connected to **PD3 of Atmega8535** by using 25Ω resistor in series to receive logic 1/0 from the microcontroller related to **listening mode** of the circuit.)

d. **Super Bright LED**. This brightly white light emitting diode indicates that the alarm is on the standby mode, therefore the user is able to make sure that the alarm buzzer will turn on when the alarm time meets the digital clock time. (This LED is connected to **PD7 of Atmega8535** by using 10 kΩ resistor in series to receive logic 1/0 from the microcontroller related to ***putting the alarm on the standby mode*** function of the digital clock.)

e. **Rainbow LED**. This flip-flop light emitting diode with three different colors of light (red, blue, and green) indicates that the alarm buzzer turns on when there is a time match between the alarm and the digital clock. (This LED is connected to **PD6 of Atmega8535** by using a ***power transistor circuit***, *as the supporting component* to receive logic 1/0 from the microcontroller related to ***putting the alarm on the standby mode*** function of the digital clock.)

6) *Buzzer*

Buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or electronic. Typical uses of buzzers or beepers include alarms, timers, and confirmation of user input such as a mouse click or keystroke [BUZ10]. At this experiment, the author applies **small alarm buzzer**, shown in Fig. 9, to the circuit for producing an alarm sound when the time between alarm and digital clock is exactly the same.

Fig. 9. Small Alarm Buzzer

The small alarm buzzer is attached to **PD6 of Atmega8535** by using a ***power transistor circuit***, *as the supporting component*,to receive logic 1/0 from the microcontroller related to ***putting the alarm on the standby mode*** function of the digital clock.

III. System Design

Every electronic circuit needs a system to be able to work well. The system is usually controlled by the circuit software. The complete circuit of our Digital Clock With Speech Recognition can be seen from Fig. 10. In this experiment, the authors have designed the software based on **two main state machines** that are operating at the same time. The first one is for checking whether there is a button pushed or a voice recognized and the second one is for activating the respective function after a certain button is pushed or a certain voice is recognized.

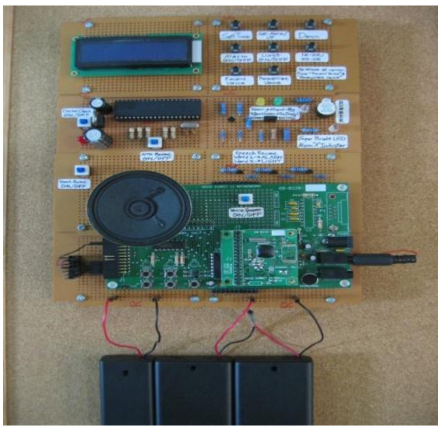

Fig. 10. Digital Clock with Speech Recognition Final Circuit

The first state machine – **State Machine** applies the debounce scheme to detect a button pushed. Debounce scheme is implemented to avoid the performance of multiple tasks when the button is pushed for too long. In this state machine, when it detects a button pushed, the flag “buttonpress” will become 1. This signal tells the second state machine whether a button is being pushed or not.

The second state machine – **Operation** coordinates with the first state machine in term of the flag “buttonpress”. It performs an instruction only when the flag “buttonpress” is equal to 1. When a function is carried out by the second state machine, before exiting the function, the flag “buttonpress” is set back to 0 for avoiding a continuous running of the second state machine.

Those two state machines are designed by **software**. Software in this experiment plays an important role as well as the hardware (the main components and the supporting components). The author utilizes the Code Vision AVR to make the program as the circuit software and download it to the microcontroller ATmega8535. CodeVisionAVR is a C cross-compiler (it means that Code Vision AVR uses C language as the high level language which is familiar for the author), Integrated Development Environment and Automatic Program, Generator designed for the Atmel AVR family of microcontrollers [COD10]. This software is designed based on the functionality of the microcontroller ATmega8535 and the other components. Fig. 11 illustrates the appearance of the Code Vision AVR software.

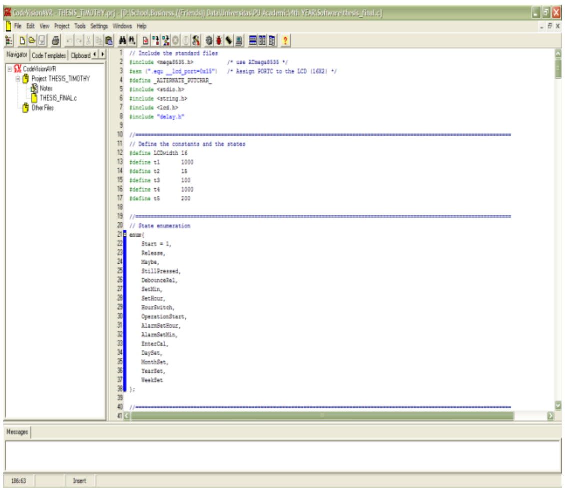

Fig. 11. Code Vision AVR Software Preview

In constructing the software or the system, the author was inspired by an experiment from Cornell University in the Spring 2002[COR10]. In addition, for supporting the software download process to the microcontroller, the author uses two devices such as DT-AVR Low Cost Micro System and DT-HiQ AVR USB ISP. DT-AVR Low Cost Micro System shown in Fig. 12 is a single chip module for the microcontroller ATmega8535[DTA10], while DT-HiQ AVR USB ISP shown in Fig. 13 is an in-system programmer that can be connected to the computer through USB port [DTH10].

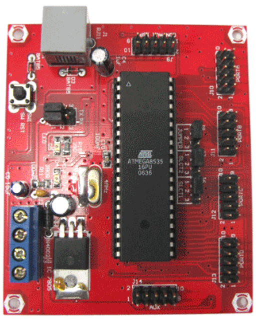

Fig. 12. DT-AVR Low Cost Micro System

Fig. 13. DT-HiQ AVR USB ISP

IV. Analysis and Evaluation

This section will discuss the performance of the digital clock and the speech recognition.

First of all for the digital clock, after testing the results of all digital clock functions, the author found that there is not any single problem existing in each of the functions. In addition, when the digital clock circuit is turned on for a long time, it will result in the heating of the **7805 IC** as the voltage regulator of the circuit. For solving this problem, the **upper part of 7805 IC** can be covered or attached by a thermally conductive tape. This tape is one of the most cost-effective heat sink attachment materials [THE10]. Heat sink is generally used to remove unwanted heat from a device to keep it from overheating. This tool can avoid the unwanted situation such as when the user unintentionally touches the heated upper part of 7805 IC. The author suggests using the thermally conductive tape in the roll form (shown in Fig. 14) because it is suitable for low-mass heat sinks and for components with low power dissipation such as 7805 IC with the up to 1 A output current and the 5 V output voltage.

Fig. 14. Roll of Thermally Conductive Tape

Second of all for the speech recognition, after testing the results of all speech recognition functions, the author found that there is a problem in optimalizing the performance of Voice Direct II as the speech recognition circuit. There are several tips for the optimal performance of Voice Direct II [VOI10]. The next paragraphs would explain about those tips. Successful recognition begins with the careful selection of words for each recognition set. Several factors contribute to selecting an optimal recognition set. Problematic recognition sets can often be corrected by replacing one or more words with a synonim, or approximate synonym (the examples are described in Table 3), without requiring any other changes. The smaller the set, the higher the recognition rate.

Table 3.Examples of Problematic Recognition Sets Correction

The optimal set consists of:	Avoid sets like:	Aim for sets like:
Dissimilar sounding words	hat/cat/rat home phone/office phone	hat/kitten/mouse home/office
Varying numbers of syllables	orange/apple/cherry	orange/watermelon/ grape

In addition, there are **three factors** as the key considerations for successful voice recording which are:

a. **Distance**. The distance of the built-in microphone at the Voice Direct II motherboard from the user's mouth must be the same during the ***training mode*** and during the ***recognition mode***.

b. **Natural Voices**. The user should speak in a normal voice and be discouraged from sounding unusual by imitating a foreign accent or using any unnatural intonation.

c. **Environment or Background Noise**. Environmental noise must be considered. In fact, for each command word, Voice Direct II monitors the background noise level. It works well with high (around 80 dB) levels of steady background noise (such as a fan), but it may make errors at lower levels if the background noise is not steady (such as a TV set). However, the Voice Direct II does not always work well with high levels of steady background noise; for example, the one minute identical loud sound continuously produced by the **small alarm buzzer** when the clock time matches with the alarm time; during this period, the Voice Direct II often can't recognize the word said by the user. For having the best results of the recognition process, the word must be said by the user in a relatively quiet location.

V. Conclusion

Based on the testing results of the whole functions of Digital Clock with Speech Recognition circuit, there are several points that can be concluded which are:

a. The digital clock circuit has five functions such as setting time (hour, minute, date, month, year, and day of the week), setting the hour mode (12-HR mode or 24-HR mode), setting alarm, putting the alarm on the standby mode, and turning on/off the light of LCD display.
b. The speech recognition circuit has two important modes such as training mode (this mode allows the user to record his or her voice in the form of short words) and recognition mode (this mode allows the user's voice to be recognized by the circuit).
c. All of the digital clock circuit and the speech recognition circuit functions are able to operate well according to the system proposed by the author. As a result, those functions can work together simultaneously as one experiment circuit called "Digital Clock with Speech Recognition".
d. The best recognition process results of the speech recognition circuit can be obtained by saying the user's recorded word in a relatively quiet location.

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