Family Digital Wall Clock

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***Abstract*— Time is an essential part of life. The passing of time is constant and time that have passed cannot be turned backed. It is important that one must use his time wisely. This paper presents a design of a digital wall clock that can shows accurate time, date and day now using an RTC. It also shows the temperature and default greetings at the event of the day. This digital wall also has notifications that can be set every hour or every quarter hour; notification sounds can be changed and customized.**

Keywords—time, digital clock, wall clock

I. INTRODUCTION

The use of clocks play an important role in the society. It is the only way of keeping track of how much have passed in terms of seconds, minutes, hours and days. In earlier civilizations, like Ancient Egypt, they have first developed a clock that used the shadows created by the different positions of the sun throughout the day which is known as the sundial. However, these of kinds of clock which are dependent on environmental factors such as the position of the sun, is not always applicable for the sun cannot be seen during night or when it is a cloudy day.

Our group have designed a digital wall clock that displays accurate time even if it suddenly turned off. Our design takes its clock from a real time clock (RTC), is a computer clock (most often in the form of an integrated circuit) that keeps track of the current time. [1] In addition, this digital wall clock also has special features like displaying the current temperature and humidity around its environment and setting a recorded audio as its notification sound.

A. Analog Clock Vs. Digital Clock

As time passes, society and technology continue to grow and change, along with these changes are improvements on clocks. Before the digital clock that society mostly prefer today, we have the analog clock. The analog clock has three rotating hands, one for second, one for minute and one for hour. It can indicate the time by the position of its hands. Analog clocks only have the numbers one to twelve on display representing the 24 hours of the day. Unlike the sundial and other older versions of clocks, analog clock can show the exact time throughout the day regardless of the weather.

Figure 1. Analog Clock

Despite that, analog clocks do not always display an accurate time. One circumstance where it can display inaccurate time is when it suddenly stops and start working again. The time that have passed while the clock is not working will not be considered by the clock and will just resume from the time it stops unless manually adjusted. Another problem with analog clock is that most of them have only the number of hours on display, minutes are just represented by dots or other figures as seen in Figure 1, thus time cannot be easily read. Aside from this, readability on low light is also a problem when it comes to analog clocks. Only a few numbers of analog clocks have the feature of having a backlight around it.

In order to address these problems of using an analog clock, digital clocks were built. A digital clock is a type of clock that displays the time digitally in numerical symbols as opposed to an analog clock, where the time is indicated by the positions of rotating hands. Digital clocks are often associated with electronic drives, but the "digital" description refers only to the display, not to the drive mechanism.[2]

Figure 2. Digital Clock

The digital clock addresses the problems encountered when using an analog clock. It can display time accurately with the help of GPS (Global Positioning System) or an RTC (Real-Time Clock). Also, with these 2 components the clock will still display the current and accurate time when it turns back on after it suddenly shuts down.

Digital clock can be read faster compared to analog clocks. It is quicker to be able to glance at the face and see a number like 6:14am than it is to have to look to the hour, minute and second hand.[3] It is also functional in low light, so there would be no problem telling the time in a room where lights are regularly dimmed, such as theaters or auditoriums. [4]. However, since it has different features digital clocks are more costly than analog clocks.

II. Design and Prototype

A. Core Components

a) 4in1 LED Matrix MAX7219: This LED matrix comes in four cascaded 8x8 RED common cathode dot matrix that equiped with MAX7219 IC each. This module is great to display running text and picture for it has an input and output intefaces that supports cascadeding multiple modules to make a bigger dot maxtrix display as long as the current of 5V is sufficient enough to support it. This module is 12.8 x 3.2 x 1.3 cm (L*W*H) in size. [5]

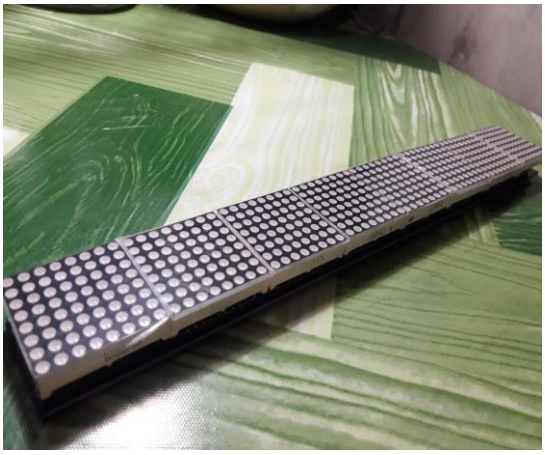

Figure 3. 4in1 LED Matrix MAX7219

b) Arduino Mega 2560: The Arduino Mega 2560 is a microcontroller that has 54 digital input/output pins; 15 of these pins can be used as PWM outputs.It has a recommended input voltage of 7V to 12V and an operating voltage of 5V.[6] This microcontroller is designed for projects that needs more I/O lines.[7]

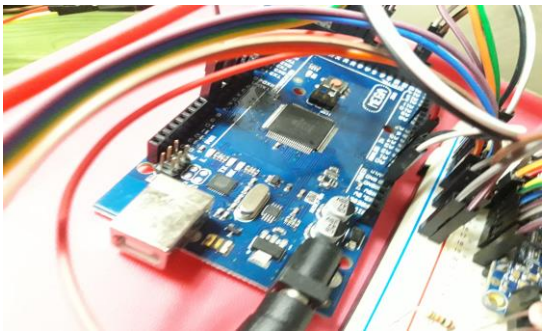

Figure 4. Arduino Mega 2560

c) DHT22: DHT22, also named as AM2302 is a basic and low-cost digital-output relative humidity and temperature sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air. Its sensing elements is connected with 8-bit single-chip computer. It has an accuracy of 2-5% for humidity readings and ±0.5˚C accuracy for temperature reading at -40˚C to 80˚C.[8][9]

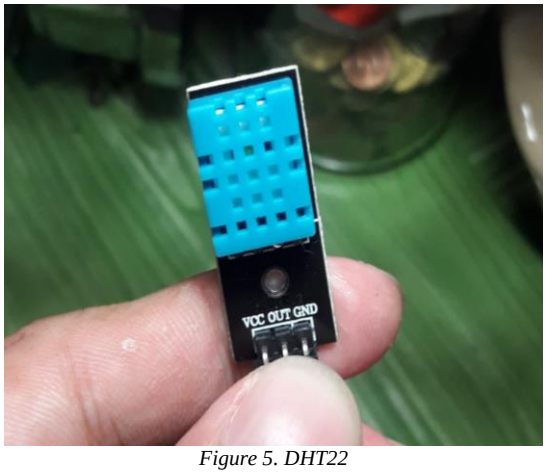

Figure 5. DHT22

d) Audio FX Sound Board - WAV/OGG Trigger with 2MB Flash: This is a stand alone device that can add sound or sound effects to a design or a project. It has a 2MB built-in storage, and mass storage USB that can be used to drag and drop files directly from the computer. It requires a power supply of 3Vdc to 5.5Vdc.[10]

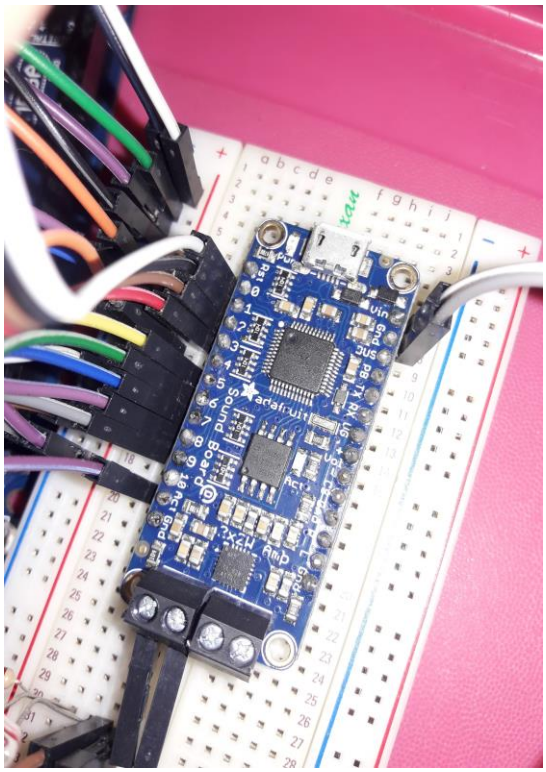

Figure 6. Audio FX Sound Board - WAV/OGG Trigger with 2MB Flash

e) RTC DS3231: It is a low-cost, accurate, and high precision real-time clock module. It is more accurate compared to other RTC since it integrated with temperature-conpensated crystal oscillator (TCXO) and crystal. Real-time clocks maintain accurate timekeeping when main power to the device is interrupted due to its incorporation of a battery input. This RTC operates in either the 24-hour or 12-hour format, and have an operating voltage of 3.3V to 5.5V.[11]

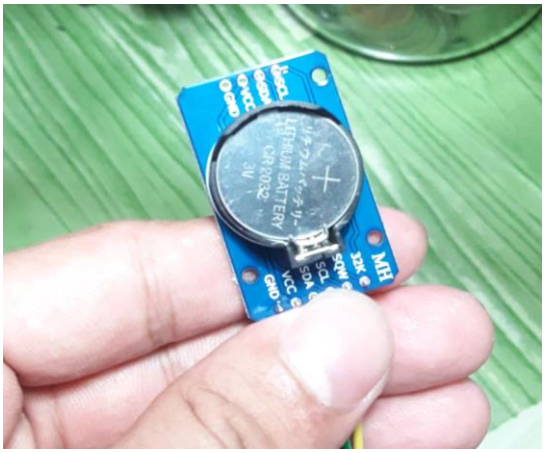

Figure 7. RTC DS3231

B. Block Diagram

Figure 8. Block Diagram

Figure 8 shows the block diagram of the design. It starts with the DHT22 which is a temperature-humidity sensor, real-time clock (RTC), and 2mb soundboard. The inputs from these components is then incorporated on the code uploaded on the Arduino Mega 2560, the output will then be displayed on the LED matrix and on the speakers.

C. Schematic Diagram of the System

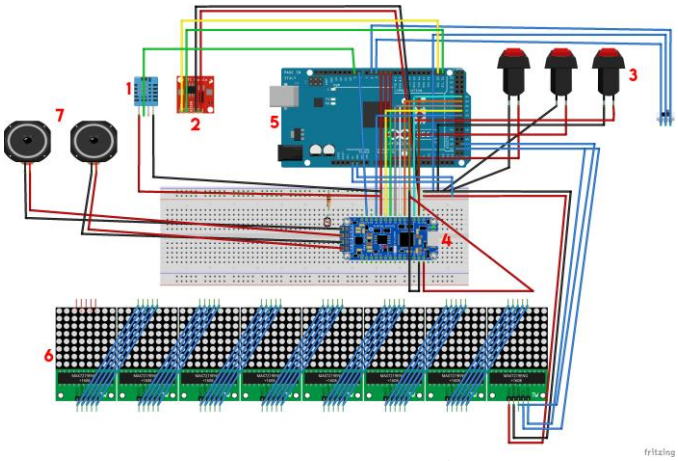

Figure 9. Schematic Diagram of the System

The schematic diagram of the system is shown in figure 9. Label 1 is the DHT22 which gets the temperature and humidity of the surrounding air around the clock. Its output will be sent to the Arduino Mega 2560. Label 2 is the RTC which saves accurate time incase of power interruption. Label 3 are the interactive switches of the clock. It has 3 normally open switches for setting up the time and date, and a toggle switch for the sound notification. Label 4 is the soundboard which enables the addition of sound effects on this design. Label 5 is the Arduino Mega 2560, the controller of the whole design. Label 6 is the LED matrix MAX7219 which displays the time, day and date from the RTC, the temperature and humidity from the DHT22, and a default greeting depending on the time of the day.

D. Flowchart of the System

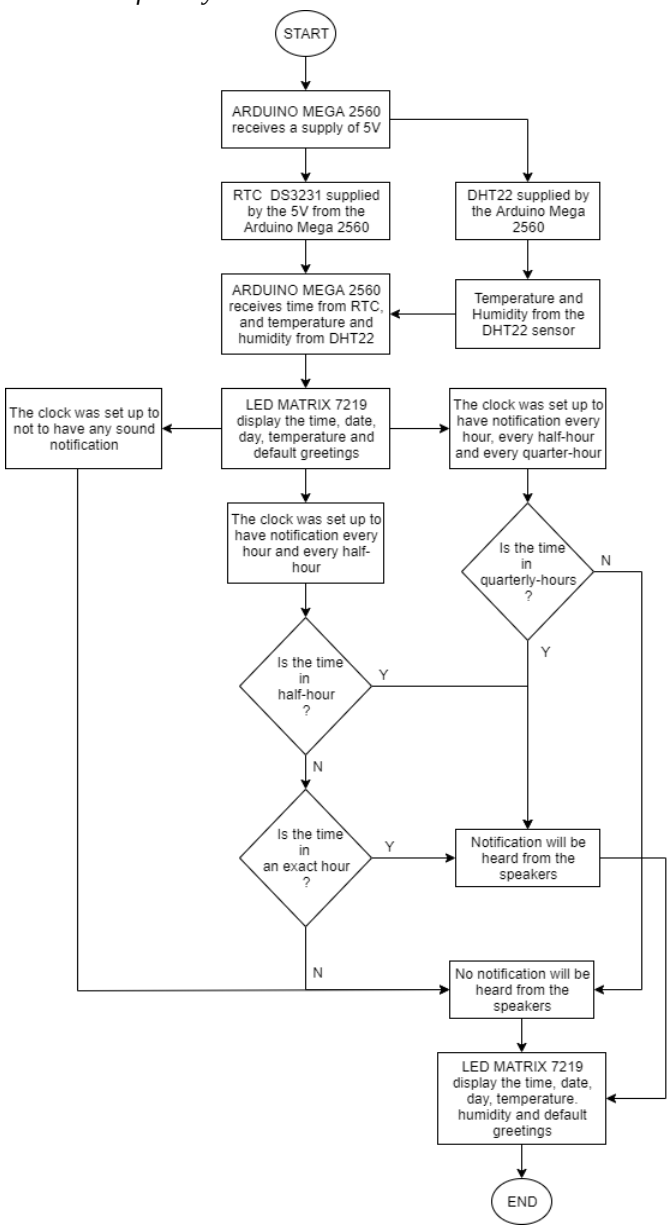

Figure 8. Flowchart of the system

The image above shows the flowchart of the system; when the digital clock is plugged in 5V will be supplied to the Arduino Mega 2560, in turn the Arduino will then supply 5V to the RTC. The time saved on the RTC will be displayed on the LED matrix 7219. The DHT22 sensor will then give output the temperature and humidity to Arduino which will then also be displayed on the LED Matrix. Every 30 minutes or 15 minutes a notification will be heard from the speakers, depending on the option set-up on the clock. Overall, the LED matrix will display the time, day, date, temperature, humidity and default greeting based on the time.

III. Test Results

A. *Testing of the Prototype*

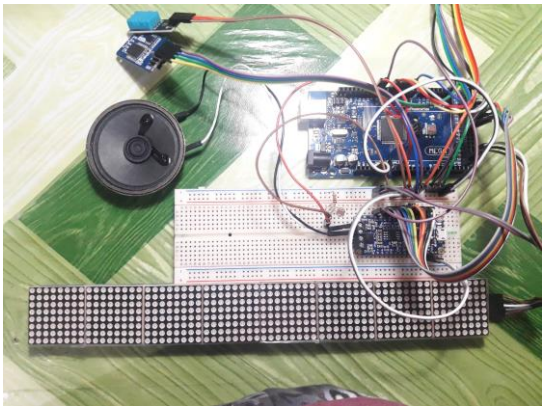

Figure 10. Assembling and Testing of the Prototype using a breadboard

This image shows the testing and assembly of the design using a breadboard. The components and the schematic diagram of the design was still being tested in this stage. Appropriate changes were made to end up with the final design.

Figure 11. LED Matrix displaying time

This photo shows the testing of the time that will be displayed on the LED. This test shows the correct time of the day the photo was taken.

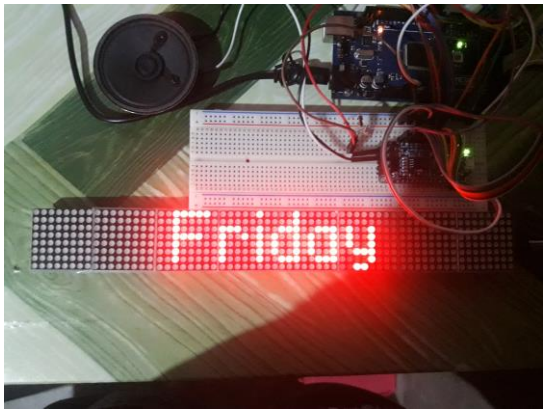

Figure 12. LED Matrix displaying the day

Figure 12 shows the testing of the day that will be displayed on the LED matrix. This test shows the correct day the photo was taken.

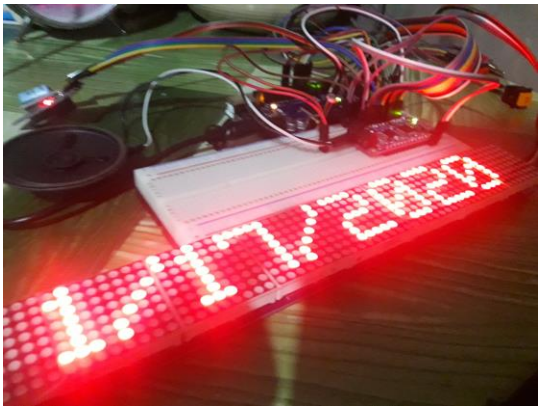

Figure 13. LED Matrix displaying the date

The testing of the date that will be displayed on the LED matrix was shown in this photo. This test shows the correct date the photo was taken

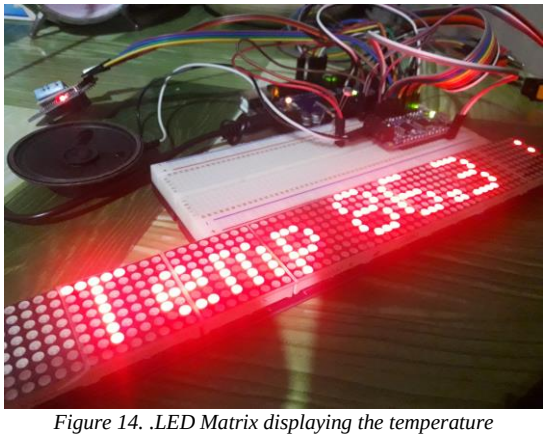

Figure 14. .LED Matrix displaying the temperature

The testing of the display of the temperature in Celsius outputted by the DHT22 sensor was shown in this image.

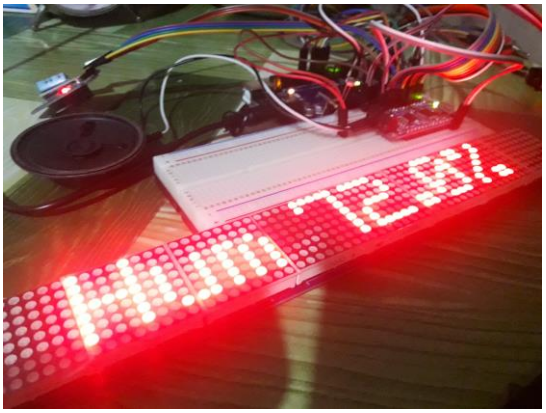

Figure 15. LED Matrix displaying the humidity

Figure 15 shows the testing of the display of the humidity of the surrounding air outputted by the DHT22 sensor.

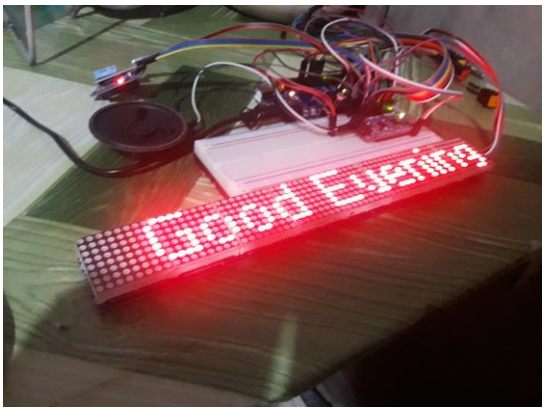

Figure 16. LED Matrix displaying a greeting

Figure 16 shows the testing of the display of the temperature in Celsius outputted by the DHT22 sensor.

TABLE I. SOUND NOTIFICATION

Test for Sound Notification	
Time	**Sound Notification**
Every 15 minutes	✓
Every 30 minutes	✓
Every hour	✓

This table shows the test results on the sound notification of the clock. The clock has three set-ups for the sound notification: it can notify every hour and every half-hour, or it can notify every hour, half-hour and quarter-hour, or it can turn-off the sound notification.

TABLE II. READABILITY OF THE CLOCK (20-20 VISION)

Readability of the Clock (20-20 Vision)	
Distance	**Remarks**
1 meter	Readable
2 meters	Readable
3 meters	Readable
4 meters	Readable
5 meters	Readable

This table shows the test results of the readability of the clock for someone that have 20-20 vision. The distances indicated above is the distance of the person from the clock.

TABLE III. READABILITY OF THE CLOCK (VISION PROBLEM)

Readability of the Clock (Vision Problem)	
Distance	**Remarks**
1 meter	Readable without any optical aids
2 meters	Readable without any optical aids
3 meters	Readable without any optical aids
4 meters	Readable with optical aids
5 meters	Slightly readable with optical aids

This table shows the test results of the readability of the clock for someone that has vision problem. The people who are considered for this testing are mostly aged people that have vision problem. The distances indicated above is the distance of the person from the clock.

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APPENDIX

ARDUINO MEGA 2560 SPECIFICATIONS	
Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20mA
DC Current for 3.3V Pin	50mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
LED_BUILTIN	13

DHT22 SPECIFICATIONS	
Power Supply	3.3 – 6 Vdc
Sensing Element	Polymer Capacitor
Operating Range	Hum: 0-100%RH; Temp: -40~80 Celsius
Accuracy	Hum: ±2%RH(Max±5%RH); Temp: <+-0.5Celisius
Resolution/sensitivity	Hum: 0.1%RH; Temp: 0.1Celsius
Long-term Stability	+-0.5%RH/year
Sensing Period	Average: 2s

RTC DS3231 SPECIFICATIONS	
Operating Voltage	3.3 – 5.5V
Real-time clock chip	DS3231
Clock Accuracy	2 ppm
Memory Chip	AT24C32 (32KB storage capacity)

SOUNDBOARD SPECIFICATIONS	
Operating Voltage	3 – 5.5 Vdc
Built in storage	2MB or 16MB

LED Matrix MAX7219	
Operating Voltage	4.7 – 5.3V
Operating Current	320mA
LED Color	RED

DHT22 SPECIFICATIONS	
Power Supply	3.3 – 6 Vdc
Sensing Element	Polymer Capacitor
Operating Range	Hum: 0-100%RH; Temp: -40~80 Celsius
Accuracy	Hum: ±2%RH(Max±5%RH); Temp: <+-0.5Celisius
Resolution/sensitivity	Hum: 0.1%RH; Temp: 0.1Celsius
Long-term Stability	+-0.5%RH/year
Sensing Period	Average: 2s

User's Manual:

1. Plugged the power supply of the clock
2. Once turned on, there will be a sound notification and the words "Set-up mode:" will be display on the LED Matrix.
3. Push the orange button to enter set-up mode.
4. Upon entering the set-up mode, you can first edit the hour, then the minute and lastly th second.
5. Push the yellow button for increment while the red button is for decrement.
6. Once you have finished setting up the seconds of the clock, push the orange button to exit the set-up mode.

For Sound Notification Settings:

1. Position the toggle up for bells sound notification for every quarter-hour, half-hour , and an hour.
2. Position the toggle down for personalized sound notification for every half-hour and an hour.
3. Position the toggle in the middle for no sound notification.