# A Microcontroller-Based Digital Clock with LEDs Analogue Display 

David O. Agbo ${ }^{1}$, Jotham O. Odinya ${ }^{2}$, Victor O. Ocheri ${ }^{3}$<br>${ }^{123}$ Department of Electrical and Electronics Engineering, Federal University of Agriculture, P.M.B. 2373, Makurdi, Benue State, Nigeria


#### Abstract

The design of the PIC microcontroller LED clock consists of few components that implement a digital clock using analogue display pattern. In this paper the LED clock was designed with 12 red LEDs in the outer circle, 12 green LEDs in the inner circle and four centralized yellow LEDs. The four yellow LEDs were used to count and indicate four minutes in consecutive pattern. The inner 12 green LEDs were used in indicating $0,5,10, \ldots, 55,60 / 0$ minutes while the 12 red outer LEDs were used to indicate $0,1,2, \ldots, 11,12 / 0$ hours respectively. Before the four yellow LEDs count, the first green LED (0 or 60) and first red LED ( 0 or 12) in circular arrangement were turned ON. After the four yellow LEDs count, the second green LED (5) comes on. This process continues until the twelfth green LED ( 0 or 60 ), then the second red LED comes on, and this process continues until the twelfth red LED ( 0 or 12) comes on. This device was design using microcontroller PIC16F873 with its port pins connected directly to the four yellow LEDs via resistors and the other 12 red and 12 green LEDs were connected to the microcontroller via decoder for pins conservation. Three switches were connected to the microcontroller to set the digital clock.


Keywords: LED, Decoder, PIC 16F873, and Microcontroller.

## 1. Introduction

A clock is an instrument to indicate, keep, and co-ordinate time. The word clock is derived ultimately (via Dutch, Northern French, and Medieval Latin) from the Celtic words clagan and clocca meaning "bell". A silent instrument missing such a mechanism has traditionally been known as a timepiece [1]. In general usage today a "clock" refers to any device for measuring and displaying the time. Watches and other timepieces that can be carried on one's person are often distinguished from clocks [2].

Clock is one of the oldest human inventions, meeting the need to consistently measure intervals of time shorter than the natural units: the day, the lunar month, and the year. Devices operating on several physical processes have been used over the millennia [3].
There are two types of clock; analog and digital clock. Analog clocks usually indicate time using angles. Digital clocks display a numeric representation of time. Two numeric display formats are commonly used on digital clocks: 24 -hour notation and 12 -hour notation. Most digital clocks use electronic mechanisms and LCD, LED, or VFD displays [3].

Analog clocks usually indicate time using angles. The most common clock face uses a fixed numbered dial or dials and moving hand or hands. It usually has a circular scale of 12 hours, which can also serve as a scale of 60 minutes, and 60 seconds if the clock has a second hand. Many other styles and designs have been used throughout the years, including dials divided into $6,8,10$, and 24 hours. The only other widely used clock face today is the 24 hour analog dial, because of the use of 24 hour time in military organizations and timetables. The 10 -hour clock was briefly popular during the French Revolution, when the metric system was applied to time measurement, and an Italian 6 hour clock was developed in the 18th century, presumably to save power (a clock or watch striking 24 times uses more power) [3].
Digital clocks display a numeric representation of time. Two numeric display formats are commonly used on digital clocks:

- the 24 -hour notation with hours ranging 00-23;
- the 12 -hour notation with AM/PM indicator, with hours indicated as 12 AM , followed by $1 \mathrm{AM}-11 \mathrm{AM}$, followed by 12PM, followed by 1PM-11PM (a notation mostly used in domestic environments) [3]. Most digital clocks use electronic mechanisms and LCD, LED, or VFD displays; many other display technologies are used as well (cathode ray tubes, nixie tubes, etc.). After a reset, battery change or power failure, these clocks without a backup battery or capacitor either start counting from 12:00, or stay at 12:00, often with blinking digits indicating that the time needs to be set. Some newer clocks will reset themselves based on radio or Internet time servers that are tuned to national atomic clocks. Since the advent of digital clocks in the 1960s, the use of analog clocks has declined significantly [3]. Some clocks, called 'flip clocks', have digital displays that work mechanically. The digits are painted on sheets of material which are mounted like the pages of a book. Once a minute, a page is turned over to reveal the next digit. These displays are usually easier to read in brightly

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lit conditions than LCDs or LEDs. Also, they do not go back to 12:00 after a power interruption. Flip clocks generally do not have electronic mechanisms. Usually, they are driven by AC-synchronous motors [3].

## 2. Materials and Methods

The block diagram of the system is depicted in figure 1. The embedment of a microcontroller into the system makes it to be a stand, alone type of system that is capable of taking decisions to keep the system functioning properly. The microcontroller receives inputs signals from three switches. Depending on the input the microcontroller received from the switches, it set the LED clock.

When the system is first switched on, it waits for the set switch to be pressed. If the set switch is not pressed it start the clocking, but if the set clock switch is pressed it continues to wait for either the hour switch or minute switch to be set. As long as the set switch is not pressed (NO) neither the hour switch nor the minute switch will not function when pressed by user. When the hour and minute LEDs are set to the proper time, the set clock switch can now be switched off so that the clock can continue counting or else it will be waiting for the set switch to be switched off


Figure 1: Block diagram of the LED clock
The schematic diagram of the PIC driven LED clock is shown in figure 2 and 3. This is digital clock that displays in an analog fashion using LEDs to indicate the minute and hours reading with the aid of a microcontroller. The microcontroller generates the periodic cycles which the clock system used in timing. The clock employed the use of 28 LEDs, four centralized yellow LEDs to count four minutes, twelve inner green LEDs to do the count of sixty minutes and twelve outer red LEDs to count twelve hours. Three switches are used as inputs to the microcontroller to set the clock. The first is a spdt switch, when the microcontroller receives signal from the spdt switch, the microcontroller stops all process and wait for the clock time to be set. After setting of the clock using both or either the two push switches, which are used to set the minute and hour LEDs. The spdt switch can then be switched off for the digital clock to continue clocking from the set time. The four yellow LEDs count the four minutes between $0-5,5-10,10-15, \ldots, 55-60$ minutes. While both set of twelve LEDs are connected the microcontroller via two separate 4-16 bit decoder to drive each set of twelve LEDs separately. The twelve green LEDs count the minutes of $5,10,15,20,25, \ldots, 55,60$, while the twelve red LEDs counts the hours of $1,2,3, \ldots, 11,12$. The design deployed the use of both battery and ac mains. The microcontroller used for the project is the PIC16F873 [7]. The microcontroller takes inputs from the switch, under the control of the program in its program memory; the microcontroller uses its internal timing cycle to turns LEDs to indicate timing of a clock.


Figure 2: control unit of the LED clock

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Figure 3: LEDs clock arrangement unit
Figure 4 gives the flow charts of the program executed by the microcontroller. As indicated in the flow charts the microcontroller polls the input switches and after taking the appropriate decision it goes back to monitoring the switches in a continuous loop.


Figure 4: Flow chart of the LED clock

## 3. Results and Discussions

The program for the microcontroller was written in assembly language and was then compiled into an executable file using the MPLAB8.91 IDE [6]. A software simulation was carried out with the simulator built into the MPLAB IDE to ensure that the program variables and registers changed as desired. The executable file was next imported into the Proteus Design Suite IDE where the hardware circuit shown in figure 2 and 3 was designed and simulated. The program development in MPLAB IDE is shown in figure 5. Figures 6 and 7 show the simulation results for instances when the time is 12:03 and 7:07, respectively. Upon successful completion of the software simulation, the system's hardware was constructed on a vero board and programming of the microcontroller was carried out using PICkit 2 programmmer [9]. The process is shown in figure 7 and the hardware construction displaying connections and various times are shown in figure 8.


Figure 5: Program Development using mikroC IDE


Figure 6: Simulated result when time is 12:03


Figure 7: Simulated result when time is 7:07

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(a) Back View

(b) Front View

Figure 8: Constructed Hardware of digital clock

## 4. Conclusions

The low cost digital clock with analogue display pattern was design, simulated and implemented. It consists of the switches, PIC16F873 microcontroller, decoders and LEDs. The aim and objectives of developing this project were achieved. The degree of reliability was high because of the few number of components used. The simulation and implementation were successful.

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Engr. David O. Agbo, is currently undergoing a PhD in Electronics and holds a Master of Engineering (M.Eng.) in Electronics from the Federal University of Agriculture, MakurdiNigeria, He is a Lecturer at the Department of Electrical and Electronics Engineering, Federal University of Agriculture, Makurdi-Nigeria. His research interests include power converters, micro-controllers, digital imaging. He is a registered and practicing Engineer.


Jotham O. Odinya, is currently undergoing a PhD in Electronics and holds a Master of Engineering (M.Eng.) in Electronics from the Federal University of Agriculture, MakurdiNigeria, He is a Lecturer at the Department of Electrical and Electronics Engineering, Federal University of Agriculture, Makurdi-Nigeria. His research interests include communication and electronics.


Victor O. Ocheri, is currently undergoing a Master of Engineering (M.Eng.) in Electronics from the Federal University of Agriculture, Makurdi-Nigeria, He is a Lecturer at the Department of Electrical and Electronics Engineering, Federal University of Agriculture, Makurdi-Nigeria. His research interests include electronics.

