Design and Implementation of a Sequential Digital Display for a Nigerian University

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Abstract—A sequential digital display is an electronic system that is used to display information to the public. It is a device that contains light emitting diodes that conveys messages by a programmable controller or mechanical processes, regardless of size. Sequential digital display is fast gaining acceptance and application in different spheres of life. In this work, a sequential digital display system was designed and implemented. The components used include transformer, diodes, voltage regulator, resistors (fixed and variable types), capacitors, NE 555 timer, IC4017, IC7432, light emitting diodes and transistors. The aim of the project was to carry out a cost effective design, therefore, the components of the design were readily available and relatively cheap. The light emitting diodes displayed a message written as: Welcome to NOUN Ado-Ekiti study center. The project was tested and commissioned and found to meet specified design requirements.

Keywords—Integrated Circuit, Light Emitting Diodes, Sequential Digital Display, Transistor

1 INTRODUCTION

In modern times, the use of solid state materials has helped man enjoy his existence by the wonderful innovation in the world of electronics. One major development that has made possible the enormous advancement in solid state technology is the digital revolution. Circuits are designed to implement the basic digital logic functions fundamental to all digital systems. Digital electronics therefore compasses the design, manufacture, and use of circuits for processing information in digital form (Obiechine, et al., 2013). An information display is a way of providing information object for promotion. It can be seen in a form of cardboard or tarpaulin at stores/shops, streamers and electronic display devices. The advent of new technologies made the information display in form of electronic displays most common nowadays especially for advertisements and promotions (Wilbert, 2007).

The development of information display electronic based system has covered numerous technologies since its beginnings (Gowrishankar, Mritha, & Chandra, 2014). Display technologies have been developed for many years. In the late twentieth century, cathode Ray Tube (CRT) dominated the market. However, new trends in display include the demand of picture quality, size and power consumption. So, Liquid Crystal Display (LCD) is then emerging to be the current market. Due to their relatively light weight, low operating power and compact design, LCD has become a popular part of home entertainment system and it continues to dominate the existing market (Chan, Cheungkaki, & Mak, 2011). Traditional LCD requires colour filter to display full color. Electronic display devices nowadays are mostly controlled by a microcontroller. And the semiconductor that gives out light like an LED has been a great breakthrough in electronic display (Baron, 2011). Field Sequential Color of LCD (FSC-LCD) generates full color without color filters, with the use of colour addition.

Despite existence of numerous implementation of embedded system coding, designing a digital sequential display system (DSDS) is still considered as one of the innovative implementation (Bhayashree, 2009). This technology (DSDS) can be found in a number of places and are being used for different purposes. In banks, it is used to display interest rates as well as exchange rates, in hotels and pubs; it is used to display menu and prices (Obiechine, Don, & Uche.V, 2013).

The extent of development in information dissemination has made it possible that the well-known method of displaying information using sign posts, placards, notice boards, etc. has to be modified by using electronic information board. In previous years, the means by which adverts, information, etc., are made has been through the method of the digital display board. But the use of static mode of sign display such as banners, flyers etc. are becoming boring and unattractive. The new technologies of the digital age have made possible the use of programmable and reprogrammable electronics display to provide solutions to this kind of problem (Obiechine, Don, & Uche,V, 2013). National Open University of Nigeria (NOUN), Ado-Ekiti centre does not have a welcome digital display as at the time of this research work; therefore, it is pertinent to design a digital display in order to fulfill this need.

2 LITERATURE REVIEW

There are many works that have been carried out on digital electronic message display board for application in different spheres of life. Nivetha, et al. (2013) designed and implemented an SMS based wireless notice board with monitoring system. This project was designed using integrated circuit (IC4017) which will sends signal to IC 7432.

Obiechine, et al. (2013) designed and constructed a dot matrix information display for the office of the vice chancellor, Anambra State University, Uli. It was done in three stages namely the design, construction and working of a dot matrix information display. The project
covered a fairly comprehensive study of a dot matrix information display. Digital instruments, signals, and related numbers and codes were discussed. The project was designed such that the dot matrix information display operates with electrical power from either direct or alternating current source.

Emilo (2010) also designed 15 LEDs by 7 LEDs scroll message advertising billboards, this project uses 105 LEDs to produce a screen 15 LEDs long, by 7 LEDs High for running messages. Larger displays showed more letters but this is the largest display that can be produced with a single PIC16F628 micro. Ketkar, et al. (2013) designed and implemented a LED scrolling message display system. The system hardware consists of an AT89C51 controller which serves as the heart of the system. The inclusion of the buzzer and alarm units into the design limits its area of application and makes the system unduly complex. In addition, Ukpa, et al. (2013) developed a SMS Controlled Digital Display System using multiple microcontrollers namely PIC16F877 and PIC16F628 and a SAGEM MYXS-2 phone.

Dresden (2008) designed and implemented alternative transparent electrodes for organic light emitting diodes (OLED). In his work, he studied the use of two types of alternative transparent electrodes, ZnO:AL and PEDOT. These were developed for organic OLEDs. The evolution of light bulbs in the 1880s brought about the use of electric lighting as a standard technology. The use of fluorescent and incandescent lamps has dominated the world today because of their low cost and long-term stability. Solid state lighting (SSL) is a new environmental friendly light source with potentially high efficiency. So far, LEDs and OLEDs have been presented as candidates for solid state lighting (Alstair, 2013).

Several view-sequential displays have been demonstrated by developers which implement a time multiplexing principle and utilize a fast optical modulator, active shutters, and projection optics. Time sequential information is angularly multiplexed by restricting the purlp of a projection system in conjunctions with images being displayed on the modulator (Philip, John, Phil, & Christopher, 2007). Sequential systems have the advantage of using a single modulator, which is more economically feasible than other multi-view systems. They also provide natural reviewing zone, which is a subject of difficulty for other multi-view displays. However, they require large projection optics, which limits the field of view. They also throw away a lot of light because of the active shutter, which are included in the system.

3 MATERIALS AND METHODS

Descriptions of components used in the design are explained in following sub-sections.

3.1 TRANSFORMER

A transformer works through the principle of magnetic induction. It is a device that converts an alternating (A/C) current of a certain voltage to an alternating current or direct current of different voltage, without change of frequency, by electromagnetic induction.

The functions of the transformer in the circuit are:
1. To step down the input voltage from 220v to the required 15v of the designed circuit.
2. Transformer allows high Voltage to be stepped down to lower Voltage.
3. It also allows the circuit diagram to be isolated from mains

3.2 DIODES

Diodes used in this work were used to perform rectification after the transformer had stepped down the voltage to 15volts. The diodes convert AC to DC enabling components operating on DC to be powered. The specifications of diodes used are the IN4007 and IN4148.

3.3 VOLTAGE REGULATOR

The purpose of the voltage regulator is to get a fixed output voltage irrespective of the input voltage to the system. Various voltage regulators exist but the one used in this work is specified as LM7812 which gives a constant 12V DC supply to power the circuit. LM7812 have three-terminal devices that provide a constant DC output voltage that is independent of the input voltage, output load current, and temperature. The IC does not require additional components to provide a constant, regulated source of power, making them easy to use, as well as economical and provides efficient use of space. Other voltage regulators may require additional components to set the output voltage level, or to assist in the regulation process. They have protection against overheating and short-circuits, making them quite robust in most applications. In some cases, the current-limiting features of the LM7812 devices can provide protection not only for the LM7812 itself, but also for other parts of the circuit.

3.4 RESISTORS

The resistor acts as a passive component that resists the flow of current. The resistors available include such ratings as 10kΩ, 330Ω, 1MΩ, 220Ω, 100kΩ, 1kΩ, and 1MΩ variable resistor. However, a 1kΩ resistor was used for the project. Calculation for this is shown:

3.4.1 DESIGN CALCULATION FOR RESISTOR

Yellow LED has the following specification
Voltage = 2 V
Current = 10 mA

The formula to calculate the values of the Resistors to attach to the LEDs is given below

\[
\text{Source Voltage} - \text{Forward Voltage} = \text{Resistance}
\]

\[
\frac{5 - 2}{10 \times 10^{-3}} = 300Ω
\]

For the Yellow LED
\[
\frac{3}{0.010} = 300Ω
\]
The values gotten for these yellow LEDs are the lowest value of resistor to use with the LEDs in order not to damage them. This value of resistor would allow the LED to be in its brightest stage, so in order to reduce the brightness a 1 kΩ is used.

3.5 Capacitor
The capacitor is used to allow AC signal to pass to the input of the timer integrated circuit (IC) while the DC signal is blocked. The capacitor used in the power circuit of this project is to filter the ripples that may be found in the power supply section and in the switching stage. The specifications used in this work are 100μf, 10nf, 1nf. Various types such as electrolytic capacitor, ceramic capacitor and mica capacitor were deployed.

3.5.1 Design Calculation for Capacitor
The equation for calculating the minimum capacitance required is given by Stackexchange (2014):

$$C_{\text{min}} = \frac{I_{\text{max}} \times T_{\text{discharge}}}{V_{\text{before discharge}} - V_{\text{after discharge}}}$$

Where: $C_{\text{min}}$ = minimum capacitance required, $I_{\text{max}}$ = Maximum current going out from LM7812 regulator $T_{\text{discharge}}$ = discharge time of reservoir capacitance in the case of half-wave rectifier

$V_{\text{before discharge}}$ = voltage at the beginning of discharge period

$V_{\text{after discharge}}$ = Lowest input operating point for LM7812 voltage regulator

With the following determined values:

$I_{\text{max}} = 0.25A$, $V_{\text{before discharge}} = 15V$ (Figure 4),

$V_{\text{after discharge}} = 2V$

$T_{\text{discharge}} = \frac{1}{f} = \frac{1}{60Hz} = 16.6ms$, but since a diode is being used, to give a full-wave rectified output,

$T_{\text{discharge}}$ becomes: $\frac{16.6}{2} = 8.3ms$

Substituting these values in Equation 2,

$$C_{\text{min}} = \frac{0.25 \times 0.3}{8.3} = 0.16mF$$

This justifies the use of 100μF in the design of the power stage (Figure 4) because the calculated value of 16μFs is the closest to available capacitance. The other two 10 nF are used as backup capacitances.

3.6 Transistor
A transistor can be used to amplify weak signal and also act as a switch. In this work, however, the transistor used is IC D888 (NPN) is used to amplifier weak signal emanating from the IC 4017.

3.7 NE555 Timer
The 555 timer IC is an integrated circuit (chip) used in a variety of timer, pulse generation, and oscillator applications. The 555 timer can be used to provide time delays, as an oscillator, and as a flip-flop element. Derivatives provide up to four timing circuits in one package. This multipurpose IC NE555 is wired as a stable-multi vibrator which detects the signal coming to its input.

3.8 Integrated Circuit 4017
The IC 4017 shown in Figure 1 can be considered as one of the most useful and versatile chip having numerous electronic circuit applications. Technically it is called the Johnsons 10 stage decades counter divider. The name suggest two things, it has something to do with number 10 and counting/dividing. The 555 IC in the circuit is used as a clock pulse generator to provide input clock pulses to the counter IC 4017. The IC 555 in the circuit operates at a frequency of 14Hz, which means that it produces about 14 clock pulses every second to the IC 4017. The clock pulses generated at the output of IC 555 timer (PIN-3) is given as an input to IC 4017 through PIN-14. This is shown in figure 1.

Whenever a clock pulse is received at the clock input of IC 4017 counter, the counter increments the count and activates the corresponding output PIN. When count is zero, PIN-3 is HIGH, which means LED-1 will be ON and all the other LEDs are OFF. After the next clock pulse, PIN-2 of IC 4017 is HIGH, which means that LED-2 will glow and all the other LEDs can be turned OFF. This repeats and the LEDs turn ON and OFF successively on each clock pulse thereby producing a circling effect.

3.9 Integrated Circuit 7432
The schematic diagram of the IC 7432 used in this work is as shown in Figure 2. In this IC, pin 1 and 2 are the inputs of first gate where the output is from pin number 3. Pin number 4 and 5 are the inputs of second gate whose output is in pin 6. Pin 10 and 9 are the inputs of fourth gate whose output is at pin 8. The input of the last gate or fourth gate is pin 13 and 12 and pin 11 is its output. Pin 7 is ground and pin 14 is +Vcc supply.

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3.8 LIGHT EMITTING DIODES (LEDs)

Light emitting diodes are semiconductor devices that illuminate solely by motion of electrons. When forward-biased, these components emit light. LEDs provide a cheap and convenient way to display information electronically, fit easily into an electrical circuit, and are durable. LEDs were designed with different colours: RED, BLUE, WHITE, GREEN and PINK etc for the purpose of this project YELLOW were used.

The circuit diagram showing all the components used is shown in figure 3.

Fig. 3: Circuit Diagram of the project

Various components used in the design of the sequential electronic display board are shown in the bill of materials in Table 1:

Table 1: Bill of Materials

<table>
<thead>
<tr>
<th>S/no</th>
<th>Item Description</th>
<th>Qty</th>
<th>Unit price(₦)</th>
<th>Total cost(₦)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AC Transformer</td>
<td>1</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>2</td>
<td>Diodes</td>
<td>8</td>
<td>25</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>Resistors (fixed and variable)</td>
<td>10</td>
<td>50</td>
<td>500</td>
</tr>
<tr>
<td>4</td>
<td>Capacitors</td>
<td>3</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>5</td>
<td>Transistors</td>
<td>7</td>
<td>300</td>
<td>2100</td>
</tr>
<tr>
<td>6</td>
<td>NE 555 Timer</td>
<td>1</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>7</td>
<td>IC 4017</td>
<td>1</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>8</td>
<td>IC 7432</td>
<td>1</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>9</td>
<td>Light emitting diodes(LEDs)</td>
<td>25</td>
<td>250</td>
<td>6250</td>
</tr>
<tr>
<td>10</td>
<td>Voltage Regulator</td>
<td>1</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>Total Cost</td>
<td></td>
<td></td>
<td>13,750</td>
</tr>
</tbody>
</table>

4 IMPLEMENTATION

The implementation of the project is divided into four stages which are:

i. Power stage
   a. Input stage
   ii. Amplifying stage
   iii. Output (Result) stage

4.1 POWER STAGE

The power stage supplies the current needed to power the circuit. This stage comprises of transformer, Diodes, Capacitors, wires and the voltage regulator (7812). The transformer steps down voltage input 220 v to output 15v which is passed to the block diode for rectification, the output produced is DC (Direct current) which still contains some ripples (i.e. unwanted AC signal), the ripples in the circuit if allowed to power a device, may damage the device or may not allow the device to function properly. To avoid this situation, filter capacitor 100µf and 10nf are connected to the output of the block diode to filter the ripples and after the ripples is filtered; the voltage regulator 7812 is then connected to ensure constant output voltage which is 12V as shown Fig 4.

A Light Emitting Diode is connected to the output in order to monitor the output power Supply, if voltage is supplied to the output, then the LED glows, and if not, the LED remains in the off position.

Fig. 4: Power Stage

4.1.1 THE INPUT STAGE

The input stage shown in Figure 5 involves the soldering of the NE555 TIMER, IC 4017, resistors, and capacitor on the Vero board which allows the signal to transmit to the IC 4017 to control the display of the light emitting diode. The first output of the IC 4017 must be active at the time when the thyristor chip is outputting the first row of data and this means the 4017 must be “clocked” so that it is turning on the first output at the beginning of the scanning cycle.

Fig. 5: Input Stage

4.2 THE AMPLIFYING STAGE

In this work, thyristors D882 were used to boost the weak signal from the CD4017 so as to be able to control display on the output of the circuit. The first output of the 4017 must be active at the time when the D882 is outputting the first group of the character e.g. (WELCOME) and this means the 4017 must be “clocked” so as to turn on the first output at the beginning of the scanning cycle. Figure 6 shows the amplifying stage pictorial view.
5 DISCUSSION OF RESULTS

The designed sequential digital display was tested in the university environment. It was connected to a 220 volts supply which is stepped down to 12 volts for the circuit. The result showed that the light emitting diodes displayed the title: WELCOME TO NOUN ADO EKITI STUDY CENTRE correctly. This is shown in Figure 7. In comparison with the work of Emilo(2010) and Ketkar, et al. (2013), this work uses less complex components and cheaper materials to achieve the same results.

6 CONCLUSIONS AND RECOMMENDATIONS

A moving message display or a scrolling message is an excellent method of communicating information. The smooth sailing effect of the alphabet or the characters is not only pleasing to the eyes, but also, information becomes accessible through a short time passage 

The design and development of a sequential digital display board was accomplished. Justification for the selection of materials used was given by design calculations. The board is used to display a welcome message for visitors and students in National Open University, Ado-Ekiti study centre in Nigeria. Readily available and cheap components were used to execute the project. Further improvement works can be done by introducing matrix board and PIC microcontroller to the project.

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