A Digital Electronic Ballot Counter Box

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Abstract

Little or no technological advancement, geometric increase in population, and manual counting process has made a democratic system practiced by developing countries of the world inefficient, slow and unattractive. To move away from this system, technology must be adopted to automate democratic process of voting. This paper describes the design and implementation of a digital electronic ballot counter box as an introduction to the automation of the electoral processes which will curtail electoral vices and ease the task of counting, and increase efficiency and speed. The system consists of six basic units: (i) the light source and photo sensing unit, (ii) the voltage comparator unit, (iii) the pulse generator unit, (iv) the counter, (v) the output display, and (vi) the power unit. The system is designed to accommodate as much as 9999 counting.

Keywords: Output display, democratic process, design, counting, implementation

Introduction

All over the world today, democracy has come to stay as the major and most recognized tool of governance. Democracy is defined as a government of the people, by the people and for the people. In practice, it is merely a government by the majority. To realize this form of governance, some democratization processes are involved which are handled by an electoral body constituted solely for the job. The electioneering and counting of votes are the most tasking and sensitive part of the democratization process as stressed by Eyirere (1996), especially when the manual counting system is in use. This is more hectic where rapid population growth is astronomical. This, in effect, has made the manual counting of votes tedious, bulky and erroneous, which most often leads to electoral vices such as thuggery and rigging. Therefore, automation of electioneering and counting of votes have become inevitable, or else it will be difficult to meet up the challenges of new era as seen in the increasing population.

In this paper, we describe the design and implementation of a digital electronic ballot counter box as an introduction to the automation of electoral process which will help in reducing the fraudulent acts, easing and reducing the task of counting and, in addition ensuring prompt and timely release of election results. The system is based on the use of optoelectronic device, pulse generating circuit and counter to synthesize as an electronic system.

System Description

The schematic diagram is shown in Fig. 1. It consists of six light source and photo-sensing unit that provides light energy for use by the photo receiver which senses the beam of light and converts it to voltage output. The Voltage comparator compares the voltage output energized by the passing ballot card with the preset voltage reference. The resulting output is used to drive the pulse generating unit, the output of which triggers one shot of the pulse. The pulses activate and lock the counter. The counter thereafter initiates a count at the output display units. The power supply unit activates and supplies power to the other units. The system configuration has been selected to meet the various functional requirements of the system.
Light Source and Photo Sensing Unit

A beam of light is transmitted continually for high speed counting in short range where ambient temperature and penetrating power are not problems. Therefore, a light source with a voltage rating of 2.5V and 0.3a as described by McComb (1991) is used in series with a resistor to drop the voltage across.

\[ R_b = \frac{V_{cc} - V_b}{I_b} \]  

Where \( I_b \) = light source current, which is 0.3A
\( V_b \) = Voltage drop across the bulb, which is 2.5v
\( V_{cc} \) = 6v

Therefore:
\[ R_b = \frac{6 - 2.5}{0.3} = 11.67\Omega \approx 12\Omega \]

Selection of photocell is based on voltage rating, power dissipation, light source, spectral response of source and cell as explained by Maplin Electronics (1990). For this application, the TO-5 with glass top is selected with voltage rating and power dissipation of 5V and 0.5W respectively. A light dependent voltage circuit is formed using voltage divider circuit with a photo resistor as shown in the detailed of circuit of Fig. 2. The output voltage across the photo resistor is obtained from:

\[ V_o = V_{cc} \frac{R_2}{R_1 + R_2} \]  

(i) With illumination \( R_2 = 3k\Omega \).
(ii) Without illumination \( R_2 = 1M\Omega \).

\( R_1 = 100k\Omega \) variable resistor, it is preset depending on the illumination of the surrounding environment. In this design, it is set at 47k\Omega. Therefore, from equation (2):

With illumination;
\[ V_o = \frac{5 \times 3 \times 10^3}{(47 + 3) \times 10^3} = 0.16v \]

Without illumination;
\[ V_o = \frac{5 \times 1 \times 10^3}{(1 \times 10^6) + (47 \times 10^3)} = 0.47v \]

Voltage Comparator Circuit

The LM339 quad voltage or current comparator is selected for its simple positive power supply. The comparator circuit as described by Warnes and Roger (1998), the input signal as sensed by the photo resistor is fed to the inverting input. When \( V_{in} > V_{ref} \), the comparator output is 0V and the output transistor is turned on and pulls the output down to ground. When \( V_{in} < V_{ref} \), the output transistor is switched off and the output goes to \( V_{cc} \).

The first comparator is used with pin 4 as the inverting input, pin 5 as the non inverting reference voltage and pin 2 as the output voltage, while pin 3 and 12 served as the \( V_{cc} \) and ground respectively.

Pulse Generating Circuit

The 555 timer manufactured by Philips Data Book (1998) is connected externally to operate as monostable multivibrator with external resistors setting the frequency or timing period as shown in the circuit diagram of Fig. 2. The trigger input at pin 2 going low operates the flip flops and driving the input high. The duration of the output state is given by \( t \) and is easily determined (Brophy 1983) by the following:

The voltage across the capacitor is;
\[ V_c = V_{cc} (1 - e^{\frac{t}{RC}}) \]  

\( T = RC \) = time constant  

At \( t = T \);  
\[ V_c = \frac{2}{3} V_{cc} \]  

Alternatively, \( T = -RC \ln \frac{1}{3} \)

And from (6);  
\( T = 1.1RC \)
\( C = 22\mu F \)

\( R \) is variable resistor of value 200k\Omega which could be varied from 1k\Omega to 200k\Omega.

With \( R_i = 1k\Omega \),
\( T_i = 1.1R_iC \)  
\[ = 1.1 \times 1 \times 10^3 \times 22 \times 10^6 \]
or 24.2msecs

\[
\begin{align*}
R_f &= 200k\Omega, \\
T_f &= 1.1R_fC \\
&= 1.1 \times 200 \times 10^3 \times 22 \times 10^{-6} \\
&= 4.84 \text{secs.}
\end{align*}
\]

The duration of the pulse can be varied from 24.2msecs to 4.84secs, so the variable resistors can be varied to give a time that will enable the system get ready for the next coming ballot card to be counted. Consequently, the speed at which subsequent ballot cards get to the sensor should not exceed the preset time. The duration and output of the pulse is indicated by a red light emitting diode (LED) in series with a 150\,\Omega resistor.

**Counting Circuit and Display Unit**

The counting circuit is designed using CMOS 74C925. The IC combines a counter, seven segment decoder and driver on one chip as described by Horowitz and Hill (1995) and McComb (1991). The multiplexing circuit has its own free running oscillators and requires no external clock. The counter advances on the negative edge of the clock applied to pin 11. A high signal on pin 12 will set the counter to zero. A low signal on pin 5 will latch the number in the counters into internal output latches. The output of the pulse generating circuit is fed into pin 11 through 2.2k\,\Omega pulled resistor to interface two different logic families together (TTL to CMOS). The reset key is labeled. RESET KNOB, which resets and clears the display to 0000. The bypass tantalum capacitor across supply rail and lines of the IC makes the supply lines low impedance voltage source at high frequencies and prevent signal coupling between circuits via the power supply.

**Implementation**

The system was broken into six modules for easy construction, testing and troubleshooting. Plate 1 shows the control circuit and Plate 2 shows the ballot counter box. All the ICs were mounted on IC sockets already soldered to the Vero board to ease replacement of any faulty or bad IC. Interconnections were made through etching of the Vero board and the use insulated copper wire connected at the bottom of Vero board, while the components were mounted on the top of the Vero board and soldered underneath, thus, giving the component good layout and space to give room for ventilation. All the ICs were laid in such a way that they point to the same direction. This makes it easier to keep track of pin numbers during connection and easy replacement in case of any damage to the IC in question. The leads or legs of various components such as capacitors, resistors, etc were reduced so as to prevent short circuit. Finally, the system was carefully laid out and planned in such a way as to simplify wiring, minimize error and make troubleshooting easier as shown in Plate 1.

The constructed hardware was caged in a box made of aluminums frames and glass with a slit at the top as shown in plate 2. It houses the light source and photo detective unit directly beneath it. The base of the box contains the hardware component of the system. Fig. 3 shows a detailed diagram about the dimensions, positions of mounted components and modules as well as materials used for the construction of the box.

**Testing and Results**

Hardware test of the completed circuit was carried out as follows: Continuities of copper wires used were tested using millimeters. The polarities of the components were tested and checked. ICs were checked to reaffirm their correct placement in IC sockets. The output voltage of the transformer used was observed and measured to be 12V as expected. The output IC voltage regulators were measured to be 5.01V and 5.95V as produced by 7805 and 7806 IC regulators respectively. The output of the detective voltage divider circuit when a card passes through was observed and measured to be 4.65V, while the output of IC comparator that drives the timing
The output of the 555 timer IC was monitored and observed repeatedly by adjusting its pulse rate knob with its effect on the counting circuit by virtue of its frequency and time as observed in an oscilloscope.

Counting circuit was test run on completion by an oscilloscope fed into IC through its clock input and outcome of the test was certified okay as observed from the display unit. The switches and reset buttons were tested and certified okay. The overall operation of the circuit was tested by blocking beam of light from reaching the photo detector with overall effect of count initiation at the display unit.

The incandescent lamp provides an incident beam of light, which falls on the top cap of the light dependent resistor. As soon as a ballot card passes through the slit of the box, it causes a break in the beam from the lamp giving an output voltage of 5V from the voltage divider’s circuit of the light dependent resistor (LDR). This result to zero output voltage at the comparator, thus turning on the open collector transistor in the comparator, which helps to drive the pulse generating circuit to produce one shot of pulse. This provides the counter clock with its input, thus driving the counter circuit with a resulting count initiation at the multiplexed display unit. Subsequent passing of ballot cards produces pulses with cumulative counting effect to a maximum of 9999.

The human eye interprets the multiplexed display unit, if the seven segment (LED) displays are being lit continuously. The sensor and its control base function as amplifier, which produces an output signal that is then processed to initiate a count. The system uses voltage reference knob, control base knob for the photo sensor and pulse rate knob to help the system adapt to harsh environment where the system might be subjected to bright sunlight, dust, mist etc. thus increasing the reliability value of the device which the system could control through adjustment of the excess gain.

Conclusion

A digital electronic ballot counter box has been designed and implemented from the principle of optoelectronic device, digital timing and sequencing using counters. The low operating voltage and low power consumption of the system allows for low temperature, longer life, better maintenance, low overall cost in implementation and operation thus resulting in high reliability of the system in sensing and counting. Testing of the performance of the system was carried out and the results obtained showed that the system is suited for vote counting.

For further improvement, one feature which, if incorporated into the system, is a microprocessor based control that will not only count the total number of ballot card, but will be able to identify and distinguish among the various ballot cards cast through the identification of the thumb print and its distance from the edge of the ballot box.

References

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Fig 3. Detailed diagram of dimensions and positions of mounted components and modules in the packaged ballot box.
PATE 1: Ballot Box Controller

PLATE 2: Ballot Counter Box