Design of a Solar Power Electronic Voting Machine

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Abstract—**Electronic Voting Machine (EVM) is a device that is used to count ballot and record votes instead of doing it manually using human resource to record and count votes. The many problems associated with manual counting of votes that it laborious, erroneous and time consuming. This makes the entire system very inefficient. As voting is a sensitive issue, mis-management can lead to issues as large and complicated as political unrest. The debilitating effect that political unrest can eventually lead to needs no describing. Bangladesh, being a developing nation cannot afford to be held up in its economic development due to mis-management in elections. On the other hand, for a power starved nation like Bangladesh, the gap between demand and supply of electricity remains large. A good majority of the people are deprived of this basic facility. Over-dependency on electronic devices for sensitive purposes might not seem like a viable option either. However, renewable energy based systems can be the solution to tackling such crisis. A solar powered EVM addresses all the above concerns. This paper discusses in detail the design of a solar powered EVM prototype which is efficient and allows the user a relief from the laborious act of vote collection and counting. Furthermore, it also removes the errors from the system, since it is a digital device. One of the biggest concerns of EVM is the security system which includes insider threats, network vulnerability and challenges to auditing. To limit these issues the prototype has been developed with a three stage security encryption.**

Keywords — Electronic Voting Machine, Renewable Energy, Solar Power, Microcontroller

I. INTRODUCTION

Voting is a method for a group such as a meeting or an electorate to make a decision or express an opinion, usually following discussions, debates or election campaigns. Democratic nations elect holders of high office by voting. In a democracy, a government is chosen by voting in an election: a way for an electorate to elect, i.e. choose, among several candidates for rule. In a representative democracy voting is the method by which the electorate appoints its representatives in its government. In a direct democracy, voting is the method by the electorate directly makes decisions, turn bills into laws, etc. [1,2]

Like a good majority of the nations in the world, Bangladesh follows democracy, making voting an integral part of our everyday lives.

Unfortunately, unlike the developed nations following democracy, political instability is one of the diseases plaguing this country, hindering its economic development. Two years ago, Bangladesh's year started with political turmoil when the opposition party protested, demanding free and fair elections. Even though the results of the elections, through voting, gave the nations its ruling government party, controversy surrounded the election. As a result, the economy is still having to bear the brunt in many ways. Many experts, such as The World Bank, Bangladesh Bank etc. have projected the gross domestic product (GDP) to be lower than 6% which is much below the target of 7.2% for FY 2014. [3] It is evident that the political instability has contributed to this situation. This nation has suffered prolonged political crisis since its inception.

Needless to mention that election is one of the major causes of the nation's political instability, the voting mechanism being an integral part of the elections. Votes are cast by citizens by a voting system. A voting system consists of a set of rules which must be followed for a vote to be considered valid, and how votes are counted and aggregated to yield a final result.

Different voting systems have different forms for allowing the individual to express his or her vote. In ranked ballot voting system, voted order the list of options from most to least preferred. In range voting, voters rate each option separately on a scale. In plurality voting voters select only one option, while in approval voting they can select as many as they want. [2]

The most commonly practiced system in Bangladesh is plurality voting where the voter cast their votes by marking their choice in a piece of paper and dropping the paper in a sealed box. This leaves a large window for error. Theft of vote is yet another problems that the Bangladeshi Election Committee has to face every election, no matter of whichever scale it be. Because the system is pen and paper based, there stays a big scope for felony. The vote counting is also done manually and this allows room for human error. Due to this mismanagement, the election results are often challenged. The mayhem that follows leads to a nationwide unrest.

Different forms of EVM system using different methodologies has been employed around the world based on their requirements. One of the widely used EVM systems is Diebold AccuVote-TS. In the November 2006 general election, these machines were used in 385 countries representing over 10% registered voters [7]. The machine contains a touch screen accompanied by a card reader which the individual voter possesses after contacting the polling officers. However, although accepted widely, recent analysis shows that the

system contains numerous flaws and should not be used without further improvements [8]. Another interesting mechanism for EVM system is Biometric EVM in which instead of requesting personal identifications or passwords, the system has the ability to detect individual fingerprints, face, retina, DNA etc. of an individual for easy and convenient verification. The objectives of biometric recognition are user convenience, better security and higher efficiency [9]. However, the data acquired by individuals bio-identification through fingerprints and retinal scans might be used for criminal investigations or other purposed without notification which violates the civil right of a citizen [10].

Moreover, power supply of an EVM system is an important element that needs to be fulfilled properly during an ongoing election. This is a bigger concern mostly in developing countries where power outage is frequent due to load shedding. Without proper power supply to the EVM system, data acquired cannot be authentic and questionable. Keeping the erratic power supply position in many places in different countries, the machines have been designed to run on batteries [9]. However, it cannot be the ultimate solution since the capacity of the battery is not unlimited which can cease to provide power supply to the EVM machine after a certain period of time. To our knowledge, no solar power based EVM system has been implemented to overcome the abovementioned problem till date.

Electronic Voting Machines (EVM) have been introduced in Bangladesh very recently. It is an electronic device used to record vote automatically. It is a device in which no times is wasted for vote counting. Due to its novice nature a majority of the population is still unaware of it. As its name suggests, the voting machines are run on electricity. Bangladesh being a power starved nation, cannot yet guarantee reliable supply of electricity in its metropolitan cities. It cannot further provide electricity facilities to rural, remote areas. This calls in for the need of such device that is electronic yet does not need to rely entirely on the grid network as its power source.

This paper proposes the design of an Electronic Voting Machine (EVM) that is run through solar power. With the fast depleting fossil fuel reserves, the world is now shifting its focus on reliable, sustainable energy generation: renewable energy based generation. Based on its geographic location, solar is the ideal choice of renewable energy source. A simple microcontroller based, solar powered EVM will allow the Election Commission some respite from the mayhem caused during and after the elections. Furthermore, it will also allow the country to keep pace with the development and achieve the government's dream of a digital Bangladesh.

The primary purpose of this paper is to develop a cost effective secured EVM system incorporated with existing solar power system to provide inexpensive continuous power supply which can be greatly beneficial for a developing country like Bangladesh where power source is infrequent. This paper has been structured as follows: Sections II introduces the concept Electronic Voting Machines (EVM). Section III gives a brief on renewable energy and solar power. Sections IV and V details the system architecture of the EVM machine. Section VI and VII discusses the findings and scope of future work respectively.

II. ELECTRONIC VOTING MACHINE (EVM)

The electronic voting technology was introduced to people in 1960. Their first widespread use was in the USA where 7 countries switched to this method for the 1964 presidential election [4]. As the world's dependency increasingly grew on technology, the voting system evolved and adapted with the flow. These days the use of Electronic Voting Machines can be seen across the globe: United States, Canada, Brazil, Australia, United Kingdom among many others. Bangladesh have very recently joined this crowd.

EVMs have been introduced in Bangladesh to modernize the polling process. The features of EVM device includes:

- Vote casting is very easy

- Vote counting and result publishing is almost instantaneous and 100% accurate

- 0% chance of losing data, highly stable memory with 4 backups which can store data up to 100 years

- Vote records are completely safe and confidential

- Even if the device gets damaged, on most cases the device is designed such that vote record can be retrieved

- Reusable and cost effective.

In addition to the above, EVMs are usually equipped with touch screens which can display the information in servile language and has provisions for voting for audio-visual impaired voters. Thus, such features makes voting easier and comfortable for voters with disabilities.

III. SOLAR POWER

A. Renewable Resources

Power crisis is one of the major problems plaguing Bangladesh. Being a power starved nation, Bangladesh cannot yet guarantee reliable supply of electricity in its metropolitan cities. It cannot further provide electricity facilities to rural, remote areas. This naturally rules out designing devices like EVMs for sensitive tasks like vote collection entirely or primarily dependent on grid power. This calls in for the need of such device that is electronic yet does not need to rely entirely on the grid network as its power source. It may be mentioned here that the power system in Bangladesh, i.e. power generation, is entirely dependent on fossil fuel based power generation. Fossil fuel reserves are being depleted world-wide and at an even faster rate in this country. The country's government is now actively vying for sustainable alternatives, namely renewable energy sources.

Renewable resources are natural resources which can be replenished with the passage of time either through biological reproduction of other naturally occurring processes. About 16% of the global final energy consumption comes from renewable resources. The share of renewable in electricity

generation is around 19% with 16% of electricity coming from hydroelectricity and 3% from new renewable (wind, solar, geothermal, biofuel and modern biomass) [5].

B. Solar Energy

Among all the renewable resources, solar is the most preferable as it is easily available in nature. In recent time the equipment associated with are accessible at a reasonable cost. However, solar is a dilute source of energy. Compared to the overall power intercepted by Earth, power received per unit area is small; maximum value is about 1000 W/m^2 [5]. Hence to acquire the required quantity of power a large collector area is required. Solar powered electricity generation uses either photovoltaics or heat engines, i.e. concentrated solar power (CSP). CSPs use lenses or mirrors and tracking systems to focus a large area of sunlight into a beam. Photovoltaics convert light into electric current using photovoltaic effect [6].

Renewable energy is a viable means of generating energy in Asia. For solar power, South Asia has the ideal combination of both high solar insolation and a high density of potential customers. Cheap solar power can bring electricity to a major chunk of the sub-continent's people who still live off-grid bypassing the need of installation of expensive grid lines.

In Bangladesh, a number of domestic solar energy systems are in use in houses around the country. The use of solar energy on this scale is highly potential and advantageous as nearly 60% of areas in the country do not have access to main grid electricity. The World Bank is backing a program of making solar energy available to wider population in Bangladesh, as part of the Rural Electrification and Renewable Energy Development Project (REREDP), which subsidizes solar energy systems. The long term average sunshine data indicates that the period of bright sunshine hours in the coastal region of Bangladesh varies from 3 to 11 hours daily. The global radiation stands at 3.8 which indicate that there are good prospects for solar thermal and photovoltaic application in Bangladesh.

C. From Energy to Power

The solar photovoltaic technology is the most commonly used technology for the conversion of solar energy to solar power. A solar cell, also called a photovoltaic cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photovoltaic cell which, when exposed to light, can generate and support an electric current without being attached to any external voltage source. The operation of a photovoltaic (PV) cell requires 3 basic attributes:

- The absorption of light, generating either electron-hole pairs or excitation

- The separation of charge carriers of opposite types.

- The separate extraction of those carriers to an external circuit.

Photovoltaic cells are made up of special materials called semiconductors such as silicon, which is currently and most commonly used. Basically, when light strikes the cell, a certain portion of it is absorbed within the semi-conductor material. This means that the energy of the absorbed light is transferred to the semi-conductor. The energy knocks the electron loose, allowing them to flow freely. A typical photovoltaic system employs solar panels, each comprising of a number of solar cells which generate electrical power.

The power output from a solar cell depends on the area of the cell and the efficiency of the solar cell. The power output of a solar PV cell is a product of cell efficiency in percentage, cell area in square meters and solar insolation.

IV. SYSTEM ARCHITECTURE

The circuit diagram of the solar powered Electronic Voting Machine (EVM) is provided below:
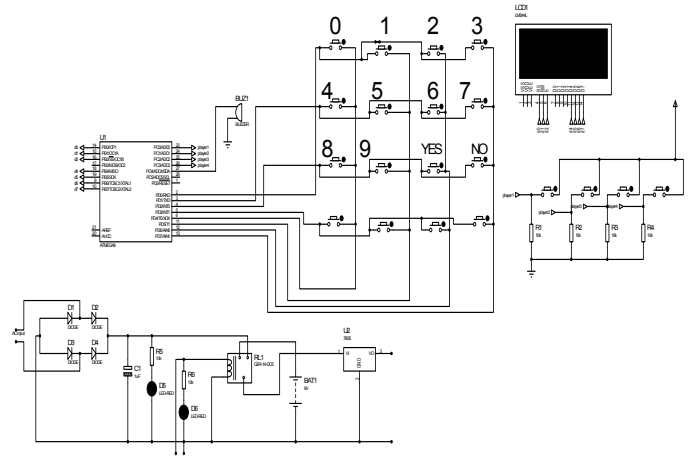

Fig. 1. Circuit design of the Electronic Voting Machine (EVM)

The major component of the EVM is the microcontroller. AVR ATMEGA8 (28 pin) microcontroller has been used in the circuit. Port B was assigned as the output and Ports C & D were the inputs. The output of the microcontroller was connected to the LCD and Buzzer. Rows of keypads were connected to PD0 to PD3 (pins 2, 3, 4 and 5) and columns of keypads were connected to PD4 to PD7 (pins 6, 11, 12 and 13). Buttons for voting were connected to PC0 to PC3 (pins 23, 24, 25 and 26). The LCD screen was connected to Port B. PB0 (pin 14), PB1 (pin 15) and PB2 (pin 16) is connected to RS pin, R/W pin and E (Enable) pin sequentially of the LCD. The reset button was connected to PC6 (pin 1) and PC4 (pin 27) was connected to the buzzer.

The circuit contains a 12V chargeable battery. A voltage regulator (IC7805) was connected to the circuit to maintain a constant 5V at the end of the power supply section. This battery is charged using solar power and to increase reliability is also connected to the grid supply. However, the grid supply is only a back-up source in case there is a failure in the solar powered system due to some technical errors. The 220V/12V step down transformer was used with the grid supply connection as the grid voltage is 220 V. A full bridge rectifier converted was kept in the circuit to convert the AC signal to DC.

The proposed EVM circuit comprises of three major portions:

- Control Section: Control section consists of 2-parts keypad and LCD. The keypads are used for setting and password input whenever password is needed. LCD is necessary for viewing the passwords and whenever author sets them to see whenever any passwords are entered, to see the votes of candidates.

- Ballot Section: Ballot section has buttons for each candidate. By pressing each of the buttons one can give vote to the corresponding candidate

- Power Supply Section: The EVM needs 5V DC to operate. The microcontroller and LCD display needs 5V to turn on.

V. SYSTEM IMPLEMENTATION

The Electronic Voting Machine (EVM) has three stage password protection system. The 1st and 2nd password is for the operator. 3rd password is highly protected. The length of each password is maximum 10 characters. Here the maximum number of candidates is four. But the number can be increased. Once the system starts the display will show 3 options: 'To Enable Vote', 'To See Vote' and 'Erase Data/Change Password'.

If the operator chooses 'To Enable Vote' he has to give password-1 to continue the voting process. If the password matches, then the voter can give vote to desired candidate. After every successful voting a sound alarm will activate. Every time password-1 has to be entered before voting. If any voter presses two button at a time or within one second, the vote will be considered as invalid vote and the voter has to give his vote again. The process flow is outlined in Figure 2.
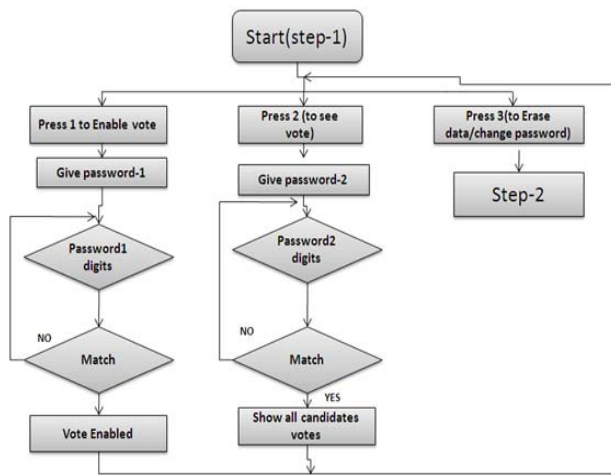
operator will have to enter password-2 for changing passwords. Then the passwords 1 and 2 can be changed. But password-3 can be changed only after entering password-3. To erase data password-3 has to be entered. If password matches all the data will be cleared and EVM will start from initial step. Figures 3 and 4 illustrate the processes.
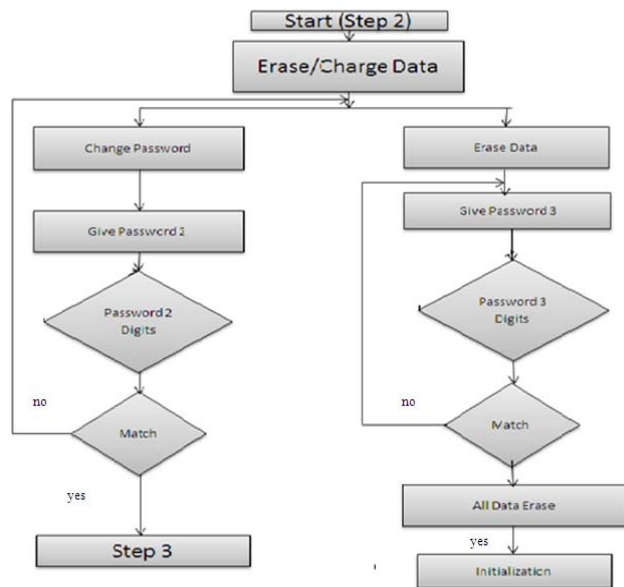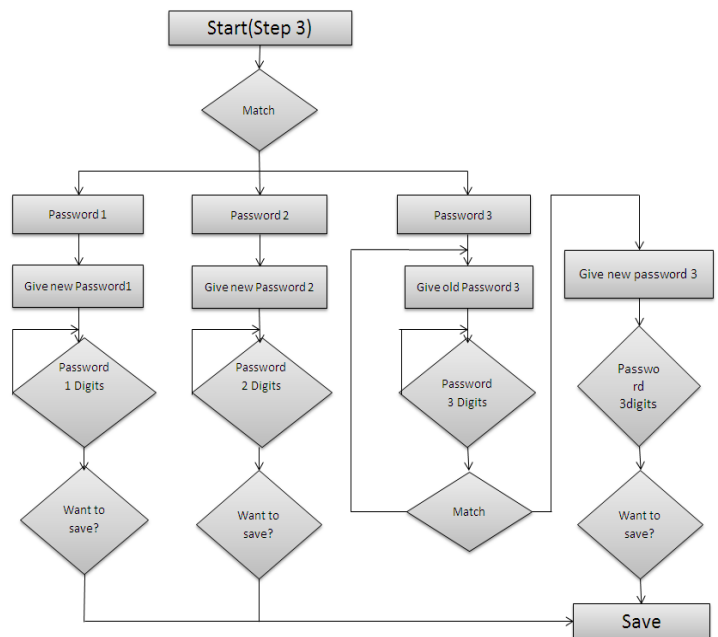

Fig. 3. Flow Chart for Step 2: Viewing Vote

Fig. 4. Flow Chart for Step 3: Erase Data/Change Password

Fig. 2. Flow Chart for Step 1: Enabling Vote

To see the vote, the authority, such as election commission, to enter the 2nd password. If the password matches, then the EVM shall display all the votes cast by the voters through the EVM. If the operator/authority, selects 'Change password or erase all data' then two options will be shown on display. The

The EVM device, prior to hardware implementation was simulated in Proteus Design Suite, Version 8.0 to check whether it is operational or not. The microcontroller coding was done in C.

The implemented hardware consisted of the ballot unit, control unit and power unit in a single PCB board as shown in figure 5.
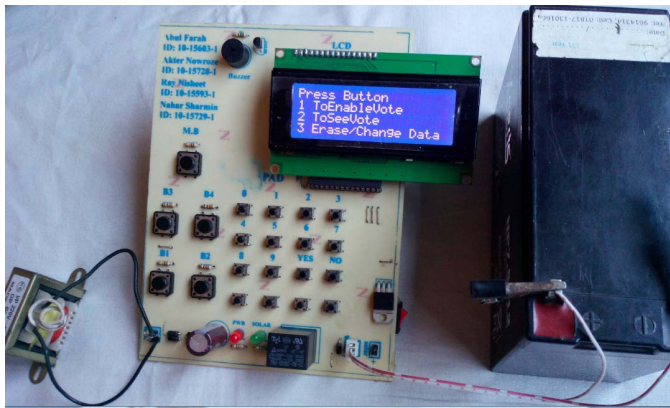

Fig. 5.   Hardware Implementation

The EVM as shown in Figure 5 consumed maximum 0.84W power. A battery of 12V, 7.5Ah rating was used. 3-5W power is enough to charge the battery. Therefore, a 10W solar panel was used in this circuit.

Fig. 6.   Four Stages of Implementation

VI.   CONCLUSION

The objective of the project was to introduce a design of an Electronic Voting Machine that uses punch card and password protection. A three level password protection was used in multiple stages. Solar power was used as power source in the circuit to reduce dependency on the grid system. This reduces

reduce the manpower requirement for voting purposes. As polling officers are not required for counting votes. This set-up is also very environment friendly as it uses solar power and being digital in nature does not require paper. The vote counting is instant, therefore reducing the delay in publishing the result. As it runs on solar power it can be used in remote locations where there is no access to electricity. Furthermore, due to the voting mechanism being electronic there is a significant reduction in errors. As no human factor is involved in vote collection and counting, there will be almost no scope for fraudulent activity. This will allow and facilitate a peaceful voting environment in the country.

VII.   FUTURE WORK

There is a vast scope for future work. Further modifications can be introduced to the system. The system could be automated so that every time a paper has been inserted in the ballot, it reads automatically and increases the count to avoid pressing the button every time a paper has been inserted. And also for stringent security purpose, fingerprint system could be implemented so the system avoids multiple counting by the same person. Moreover, by deploying a network based EVM system with the help of internet protocol may avoid people to go to a distance for the purpose of casting vote, rather they could provide vote in the comfort of their home using the internet service.

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