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Automatic Skyscraper Window Cleaning System

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ABSTRACT

Automatic Skyscraper Window Cleaning System (ASWCS) aims at providing a risk free and more automated solution for the problem of cleaning glass windowed high rise buildings. It consists of a rollers-based moving platform suspended by a motorized pulley from the top of the building. The cleaning is done with the help of a motor driven cleaning roller brush and water spraying system provided in the platform. The rail system provided on the parapet wall of the building aids in the motorized horizontal movement of the cleaning platform. The entire operation is controlled by a TI MSP430 microcontroller. Once the dimensions of the building are input, the proposed system achieves cleaning with less human intervention. Hence the ASWCS provides an easy, efficient and safe solution for maintenance of skyscraper windows.

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1. INTRODUCTION

With the ever increasing number of the glass windowed skyscrapers, the demand for their maintenance is also on the rise. Currently platform cleaning methods are being utilized most often, which are operated manually and hence are labor intensive, time consuming, costly and risky. Many solutions have been developed to overcome this problem [1]. The robotic climbing systems proposed to do the job are most often complex in their construction and do not provide for a simple solution [2]. The use of winch system to lower and lift a cleaning platform which performs the cleaning is an alternate method [3] which provides for a simple, yet efficient solution.

There are many existing systems which make use of this technique to perform cleaning of skyscrapers. However these systems are not totally automated. They can clean only one section of a side of the building and requires manual action to move it to the next section [4]. The Automatic Skyscraper Window Cleaning System (ASWCS) aims at providing a cleaning system with maximum automation and minimum cost. The proposed ASWCS system removes human intervention to a maximum extent and implements an effective algorithm that ensures a perfect and clean glass curtain wall of a high rise building. Hence our fairly low cost and low power skyscraper cleaner will have extensive use in cleaning the several high rise buildings efficiently. Henceforth the detailed explanation of the proposed solution, the circuitry involved and the program code will be discussed.

2. PROPOSED SOLUTION

The ASWCS consists of a platform which moves on the glass surface of the building by means of rollers attached to it. This platform houses a motor controlled brush to perform the cleaning. It also consists of a water spraying system, as seen in [5]. This platform is suspended from the top of the building with the

help of a motorized pulley. The pulley lowers and lifts the platform on the building surface [6] and this action is controlled by microcontroller which controls it based on building dimension. The system performs the cleaning twice along a column of the building side, moving to the bottom and then up again. On reaching the top of the building, a rail system assists in motion of the platform to the next section automatically with the help of motors. This process is repeated for the entire side of the building. The water inlet is controlled by a water valve. The microcontroller controls the vertical and horizontal motor action, water valve activation and the brush motor activation.

The moving platform made of Mild Steel (MS) encloses a nylon roller brush. The rotation of the brush for the purpose of cleaning is motorized through an ac motor along with a gear box. The platform consists of two cylindrical rollers to support its motion. The water sprinkler is also housed within the platform with its supply coming from top of the building. The entire platform is suspended by a pulley through an idler from the top of the building. The pulley is operated through an ac motor called the vertical motor. The lateral movement of the platform is aided by an ac motor called the horizontal motor. This motor moves the platform on a rail. A solenoid water valve controls the flow of water. The weight of the platform is a point of consideration as it decides the power of vertical and horizontal motors required. Hence the platform is preferred to have lighter weight so as to reduce the load on the motors.

The dimensions of the building are input to the microcontroller. The microcontroller decides the duration of operation of motors based on the input and speed of motors (rpm) which is already fed. From the decisions made, the microcontroller sends signals to the corresponding motors through interface circuitry. The interface circuitry consists of Single Pole Single Throw (SPST) and Single Pole Double Throw (SPDT) relays which performs the required switching action in the motors. The control input from the microcontroller is given through transistors to the relays. Thus the motors are switched on/off and the direction of rotation is changed according to the input. The system level block diagram is shown in Figure 1.

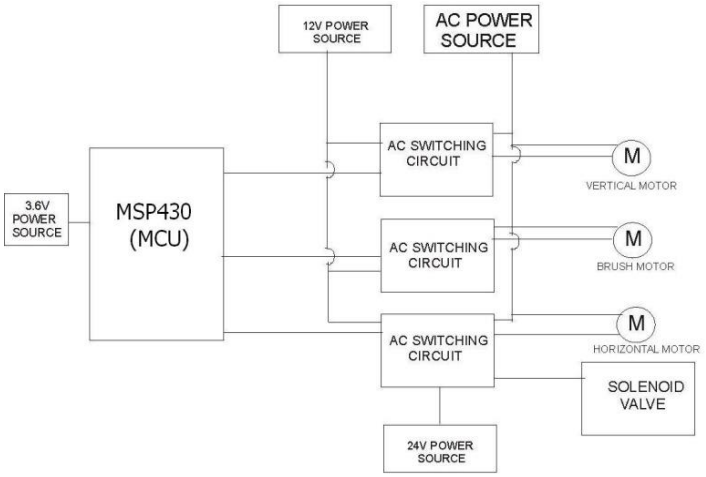

Figure 1. System level block diagram

3. IMPLEMENTATION

The physical implementation of the proposed system is delineated in the following sections.

3.1. Hardware Implementation

The platform is designed with optimal dimensions taking into consideration the expected size of the building model. The machining of raw materials and development of supporting structures are properly done to enable fixation of the motors. The motors are ac powered.

The interface circuitry as shown in Figure 2 is realized on breadboard. MSP430 is used on account of the low power consumption. A 3.5V signal from the microcontroller to the base of transistor helps in energizing coils of SPST or SPDT to which the transistor is connected. The SPST relay is used for switching on/off the motor and the SPDT relay helps in changing direction of the switched on motor. The difficulty in isolating the dc and ac modules was overcome with the help of this interface circuitry. Though alternate solutions for isolation like use of IC293 were available, the transistor based circuitry was chosen on account of its simplicity and ease of realization for the prototype. The design of final prototype of the cleaning system will be as shown in Figure 3.

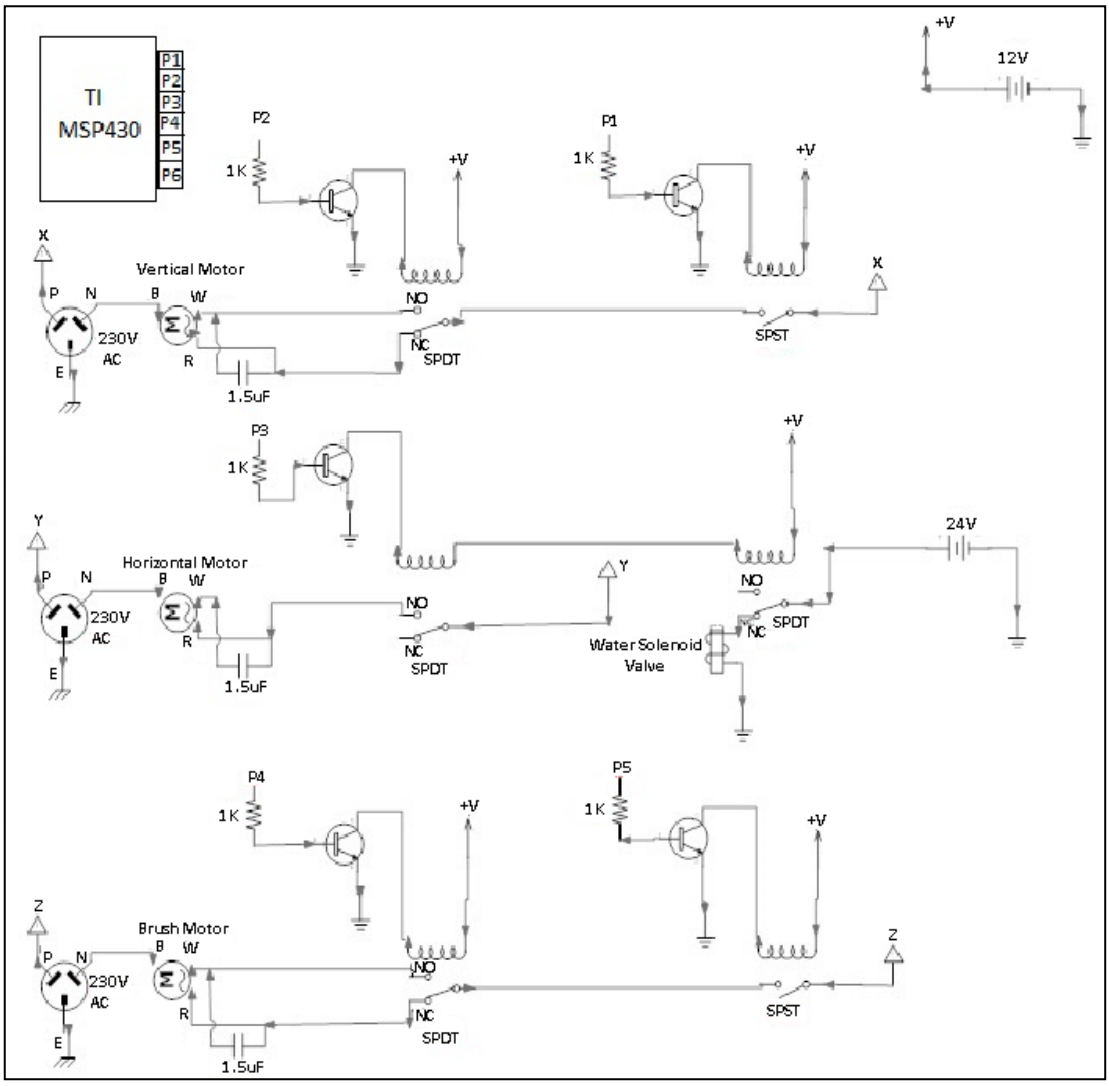

Figure 2. Circuit diagram

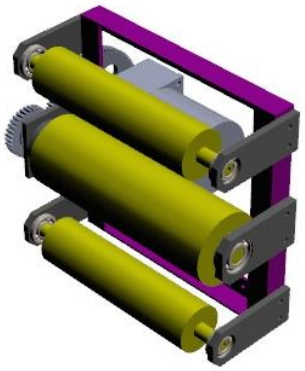

Figure 3. Design of cleaning platform

3.2. Software Implementation

The programming of microcontroller is done using Energia software. The algorithm implemented to achieve an efficient cleaning of the glass surface of the building is quite simple and it is executed repeatedly until the platform covers an entire side of the building.

Initially the horizontal motor remains in OFF condition. The vertical motor is switched ON simultaneously with the brush motor and the water valve. The platform moves down for a calculated distance and moves up again for the same distance. During this period, the brush motor and the water valve remain working. On reaching the top of the building model, the above said motors and the water valve is switched off. The horizontal motor is switched on and the platform moves laterally for a calculated distance. Once the horizontal motor has finished movement, the vertical motion repeats again. This process is done recursively till the entire side of the building is cleaned. The operations are explained through the flowchart in Figure 4.

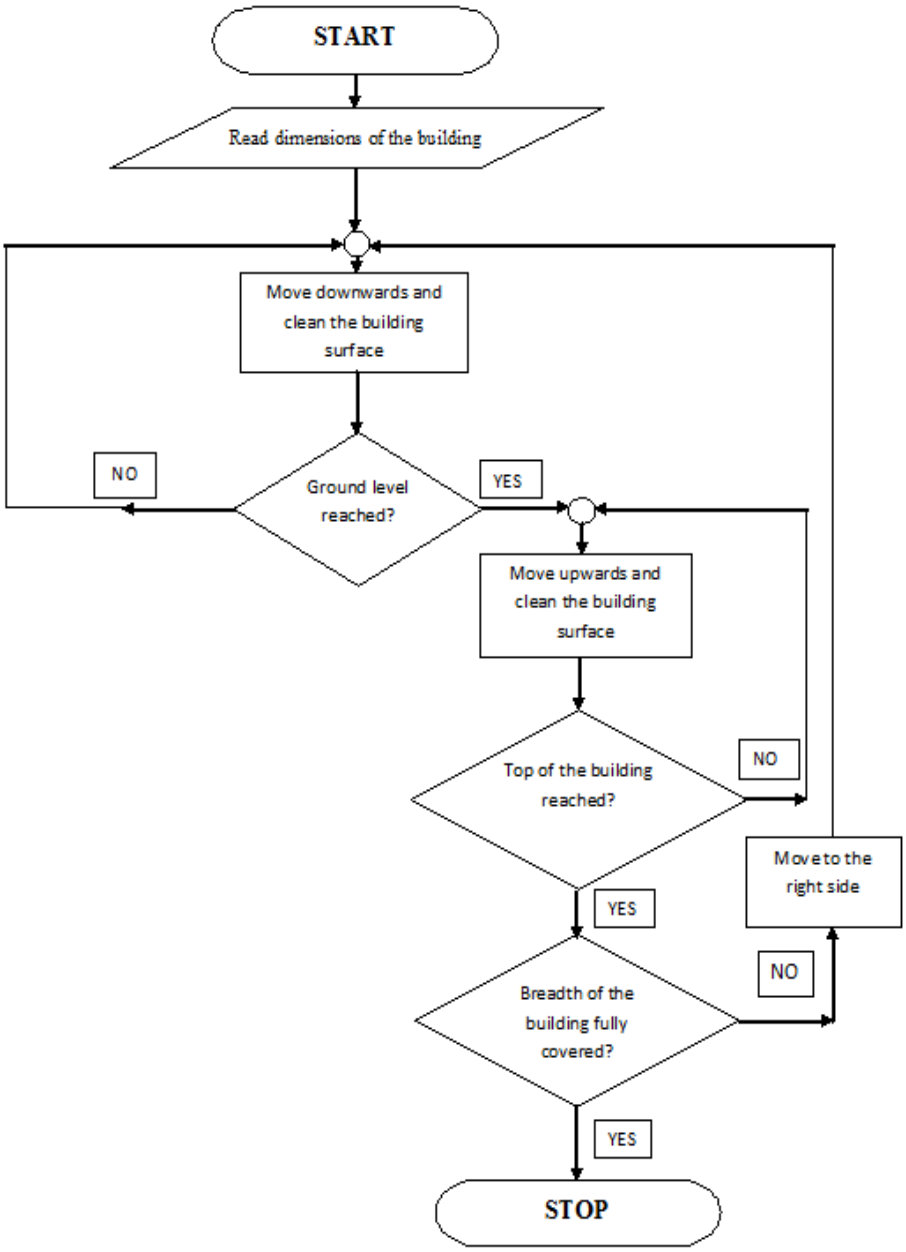

Figure 4. Flow chart of operation of microcontroller in ASWCS

4. CONCLUSION

The final prototype has been successfully developed and the entire operation successfully verified and the interface circuitry stability was measured by repeated observations. The motoring action was checked module wise and then collectively to ensure sustained operation. The final prototype is as shown in Figure 5.

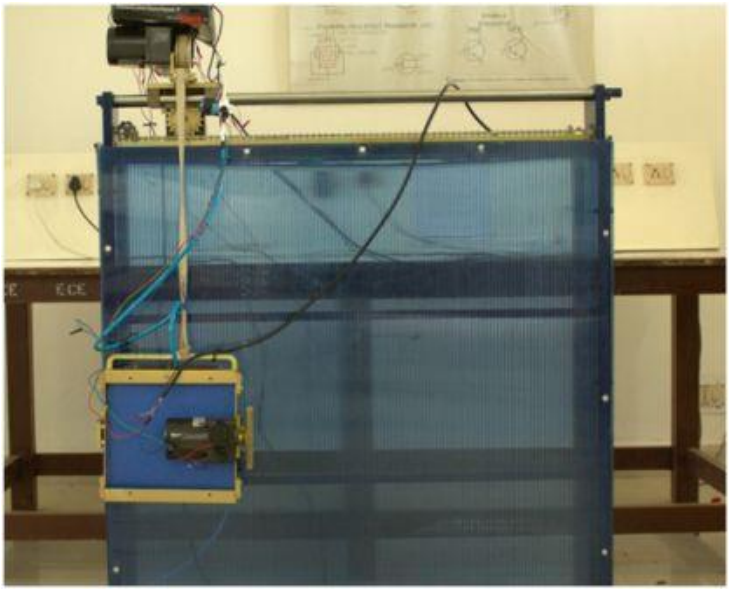

Figure 5. Final prototype of ASWCS

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