

Multi actuated hydraulic powered automatic gate using Appli-37 microcontroller

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ABSTRACT: *Automatic sliding gate is a semi-autonomous system with embedded capability of using hydraulic and automatic control systems. This research work focuses on generating system control using Passive infrared, Pressure sensor, Radio Frequency Transceiver to activate Appli-37 microcontroller which controls a single Solenoid valve aided to a buffered Driver. The system employs the high power transference property of hydraulics to operate sliding gate with full control over weight, friction due to ageing and other environmental harsh effects carefully considered. Flow chat, Operational Algorithm and codes are used to aid a robust SESLOGO program. This accomplishes the aim of reduced manual gate operation, time of operation, better entrance and exit at any time of the day.*

Keywords — *SES logo, Appli-37, solenoid valve, Fluid, Orifice, ASK.*

I. INTRODUCTION

The most common gates are used at homes as point of entry. Gates may also be used to prevent or control entry or exit, or they may be merely decorative. Most gates operated manually since there is always someone at the gate to open and close the gate when access is required. Practically, manual gates are always heavy and are swing gates for easier operation. In modern time, manually operated gates do not meet consumer needs as one must be present to operate them. The need for automatic gates has been on the increase in recent times. The research work described here incorporates the use of sensors and actuator to control the movement of the gate automatically. The automatic gate described here automates the entrances to residential homes, organizations, automobile terminus, and public car parks. It uses a radio frequency remote control convenience to avoid the stress of manually opening and closing the gate,

pressure sensor to activate the receiver that will intercept the active transmitted component of the system. The technology used eliminates gate monitoring and manning by human beings. It provides convenient access and intelligent features that makes it distinct from all other gates which bring it so close to a security device. This design comes with a proposed unique mechanism such as passive infrared that will energize the single solenoid valve which will in turn wait for any microcontroller input. The microcontroller is only used to activate the solenoid valve only when pressure is exerted on the pressure mat or when the RF transmitter is activated to generate a pulse to the receiver which in turn activates the receiver. The benefits of automation are it reduces the amount of labor, can save energy through efficiency gains, reduces the amount of materials needed, and improves quality, accuracy, predictability, and precision. Control systems also improve safety by removing humans from unsafe or dangerous conditions. [1]

II. REVIEW OF PREVIOUS WORKS

Mohd Tarmizi Bin Abd Aziz [2] worked on development of Automatic Gate Opener Mechanism where he designed automatic gate opener mechanisms. It covers fabrication and assembling of gate opener components using Mild steel and galvanized iron. The project also worked on how he automatic gate opener can be added with remote control system. Chai Fook Siang [3] designed an automatic gate mechanism for residential home with double gate leaf with weight of 100 kg for each side

of the gate. It focuses on the gate opener without much work on automatic control using feedbacks from sensor.

Lucian Nila, Mihai Crelu And Monica Salcianu[4] worked on outer gate automation using microcontrollers and radio frequency communication. In the [4] Design and Implementation of a Microcontroller Based Automatic Gate, O. Shoewu and Segun O. Olatinwo proposed a system that monitors and controls a gate by employing a microcontroller that accepts data value from the interfacing circuit and take an instant decision.

There are basically three different categories of gate operators that employ electricity for operation. These are: arm openers, worm screw driven openers and underground loop openers. [5] Automatic and electric gate openers are designed for both swinging and sliding gates. Gates openers can be either mechanical or hydraulic gate. A mechanical gate draws power from the mains to open a gate while a hydraulic gate uses hydraulic fluid to energize a connected gate. The choice of which to use hinges largely on gate requirements, for instance Swing gates (for swing arm operator, a ram arm operator or underground) or Slide gate (sliding gates are often large, heavy and therefore more hazardous than swing gates),

III. SYSTEM DESIGN AND OVERVIEW

The system incorporates a sensing systems pressure sensor, Passive IF sensor and RF transmitter which serves as input to Applic-37. The pressure is connected to a digital input of Applic-37 which when it senses a signal it will activate the Microprocessor according to the algorithm inputted into Applic-37. Once a user is going out of the house, he needs to drive over the pressure mat or walk

through the pressure mat. Once the mat senses pressure it then activate the RF receiver which is connected to the Microcontroller, the user will then press the mobile RF transmitter which will then be intercepted by the receiver. The receiver will in turn activate the microcontroller to energize the double acting Cylinder to actuate sliding gate. Once the user passer through the gate, he will need to press the button on transmitter module to deactivate the system which will make the gate to slide back and close.

When a user wants to enter from outside, all he needs is to press the RF transmitter module to activate the double acting cylinder and same sequence will follow.

In order to implement the proposed system, it was comprehensively divided into two parts which are hardware and software design considerations.

IV. HARDWARE CONFIGURATION & DESIGN CONSIDERATIONS

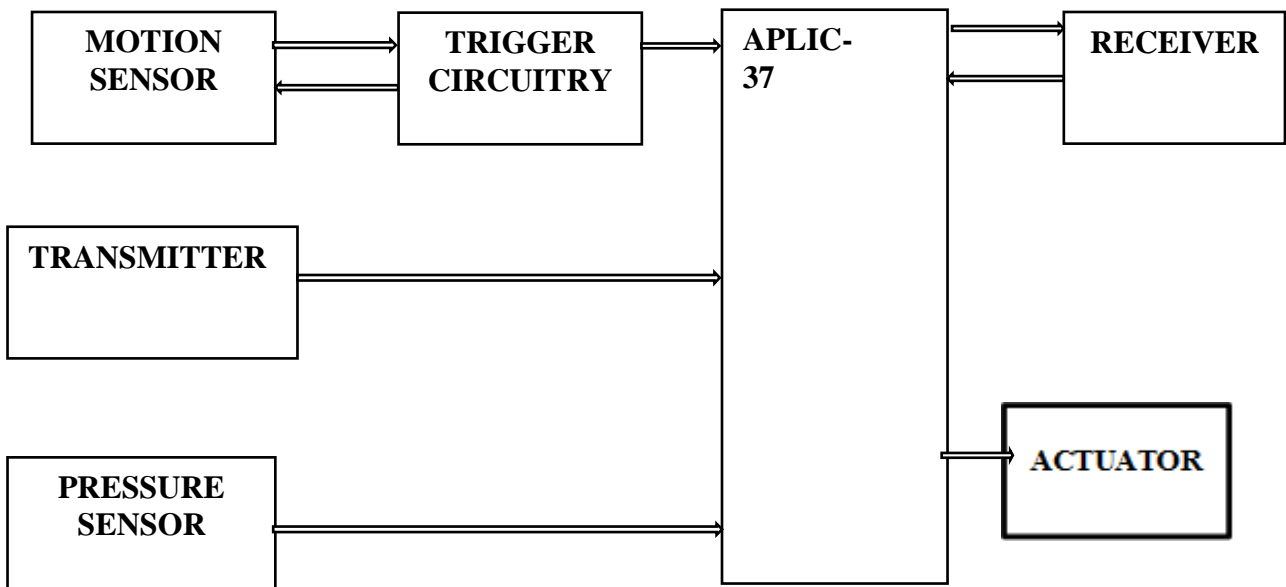


Fig 1 Block Diagram of the proposed System

1. Power Supply Unit

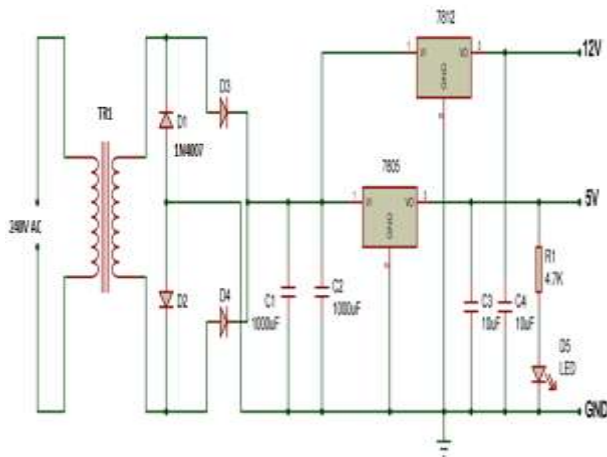


Fig 2.0 Power Supply Unit

The transformer secondary is connected to two diametrically opposite points of the bridge. During first half cycle of the input voltage, the upper end of the transformer secondary winding is positive with respect to the lower end. Thus during the first half cycle diodes D2 and D4 are forward biased and current flows through regulator. During this half of each input cycle, the diodes D1 and D3 are reverse

biased and current is not allowed to flow in arms AD and BC. During second half cycle of the input voltage, the lower end of the transformer secondary winding is positive with respect to the upper end. Thus diodes D1 and D3 become forward biased and current flows through the regulator. The voltage simulation below

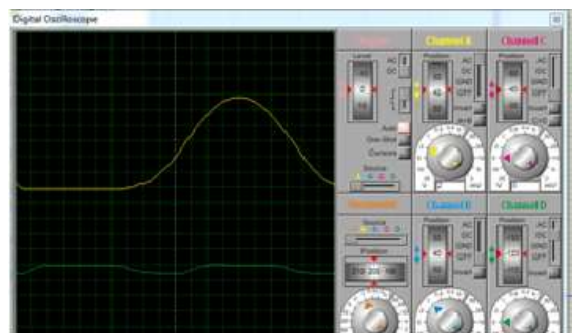


Fig 3. Simulation of the power supply

A. PEAK CURRENT

Instantaneous value of the voltage applied to the rectifier is given as

$$v_s = V_{smax} \sin \omega t$$

If the diode is assumed to have a forward resistance of R_F ohms and a reverse resistance equal to infinity, then current flowing through the load resistance is given as

$i_1 = I_{max} \sin \omega t$ and $i_2 = 0$ for the first half cycle

and $i_1 = 0$ and $i_2 = I_{max} \sin \omega t$ for second half cycle

The total current flowing through the load resistance R_L , being the sum of currents i_1 and i_2 is given as

$i = i_1 + i_2 = I_{max} \sin \omega t$ for the whole cycle.

Where peak value of the current flowing through the load resistance R_L is given as

$$I_{max} = V_{smax} / (2R_F + R_L)$$

B. OUTPUT CURRENT

Since the current is the same through the load resistance R_L in the two halves of the ac cycle, magnitude of dc current I_{dc} , which is equal to the average value of ac current, can be obtained by integrating the current i_1 between 0 and π or current i_2 between π and 2π .

$$I_{rms} = 1/\pi \int_0^\pi i_1 d(\omega t) = I_{MAX}/2 \text{ OR } I_{rms} = I_{max}/\sqrt{2}$$

D. DC Output Voltage

Average or dc value of voltage across the load is given as

$$V_{dc} = I_{dc} R_L = 2/\pi I_{max} R_L$$

E. Root Mean Square (RMS) Value of Current

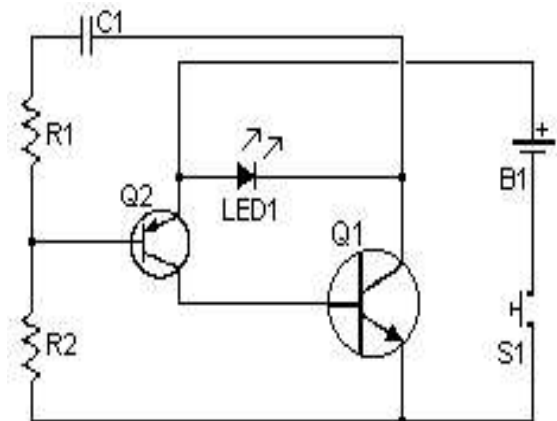
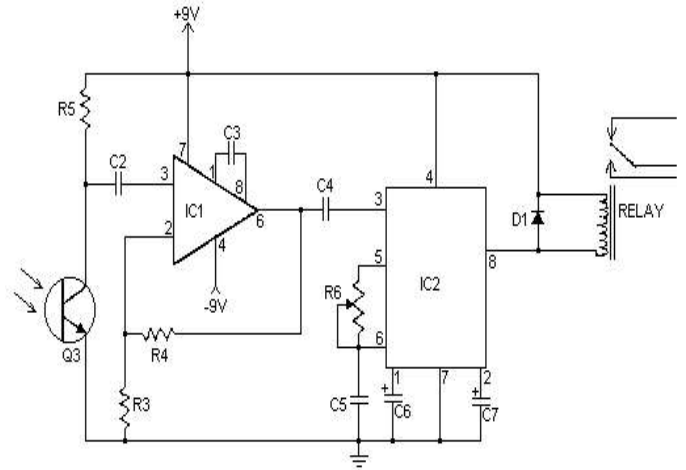
RMS or effective value of current flowing through the load resistance R_L is given as

$$\text{So } I_{dc} = 1/\pi \int_0^\pi i_1 d(\omega t) = 1/\pi \int_0^\pi I_{max} \sin \omega t d(\omega t) =$$

2. Sensor Unit

The infrared transmitter has the ability to transmit infrared beam but can only travel in a rectilinear manner or a line of sight, which is received by the infrared receiver at another end. As shown in the fig above of an infra-red transmitter/detector, the transmitter transmits pulse signal at a frequency of 36KHZ to the receiver in the line of sight arrangement. The receiver receives this pulse signal at an operating frequency of 36KHZ. This pulse signal will make the infra-red receiver pin high or at

logic. Once this pulse is broken, it makes the receiver output low. This low signal is then sent to the input pin of the micro controller which will make the microcontroller perform the predefined task indicating movement and intension to activate the system.



4. Simple detecting circuits: receiver and transmitter.

A. Pressure Sensor



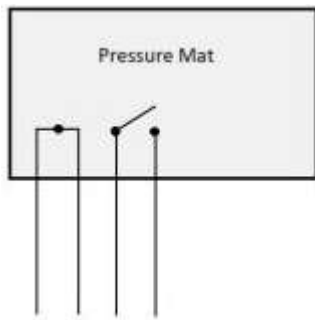


Fig 5. Pressure sensor

PM4 floor pressure mats are 570mm x 430mm x 3mm in size. This is a special pressure mat for use in turnstiles or on stair half landings that have a 90° turn. The PM4 has normal sensitivity and will detect a person either walking over or standing on it. The pressure mat should be covered by carpet or a similar floor covering. The image shows the pressure mat with 2 separate wires, it is also available with a 2 core round cable up to 3 metres in length. In a 4 wire configuration the two wires on the far left are the tamper loop. These are only needed when connecting to an alarm control panel. The two stripped wires on the right are the normally open pressure mat contact.

3. RF unit

A radio Frequency transceiver is proposed using HT12D Decoder, HT12E Encoder and ASK RF Module. Wireless transmission using 433 MHz or 315MHz ASK RF Transmitter and Receiver modules can be achieved. In these modules digital data is represented by different amplitudes of the carrier wave known as Amplitude Shift Keying (ASK). The choice of Radio Frequency sensing technic over Infrared for activation are due to some obvious reasons like; Radio Frequency signals can better distance coverage compared to Infrared, can travel over obstacles compared to the line of sight used by Infrared and . Infrared can be easily interfered by IR sources but signals on one frequency band in RF will not interfere by other frequency RF signals.

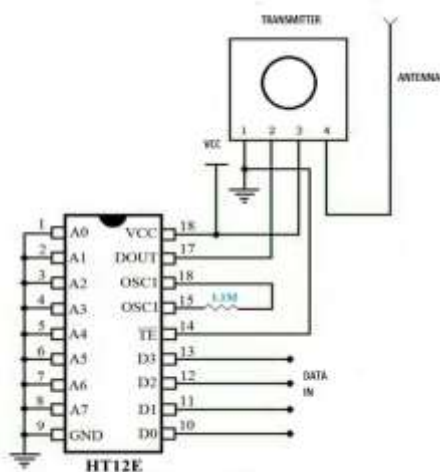


Fig 6. Simple RF transmitter using ASK

HT12E Encoder IC will convert the 4 bit parallel data given to pins D0 – D3 to serial data and will be available at DOUT. This output serial data is given to ASK RF Transmitter. Address inputs A0 – A7 can be used to provide data security and can be connected to GND (Logic ZERO) or left open (Logic ONE). Status of these Address pins should match with status of address pins in the receiver for the transmission of the data. Data will be transmitted only when the Transmit Enable pin (TE) is LOW. 1.1MΩ resistor will provide the necessary external resistance for the operation of the internal oscillator of HT12E.

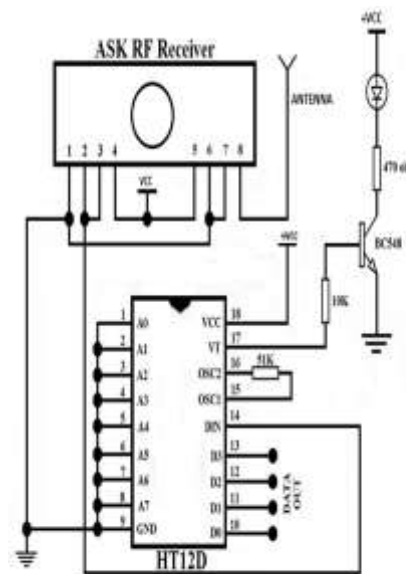


Fig 7 RF Receiver using ASK (Source: www.electrosome.com)

ASK RF Receiver receives the data transmitted using ASK RF Transmitter. HT12D decoder will convert the received serial data to 4 bit parallel data D0 – D3. The status of these address pins A0-A7 should match with status of address pin in the HT12E at the transmitter for the transmission of data. The LED connected to the above circuit glows when valid data transmission occurs from transmitter to receiver. 51KΩ resistor will provide the necessary resistance required for the internal oscillator of the HT12D.

4. Microcontroller Unit

The APPLIC-37 interface is a controller, which receives commands or a program from the computer. The interface includes eight digital output channels (Q0-Q7), eight digital input channels (J0-J7), two analog output channels (AO1, AO2) and eight analog input channels (AI0-AI7).

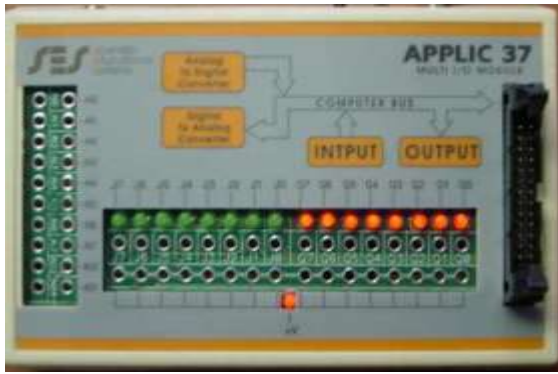


Fig 8. The Physical picture of Applic-37

A digital output channel enables us to operate a motor or a lamp in two levels – ON and OFF. An analog output channel enables us to output different voltages to a motor or to a lamp in a continuous manner at 0-10V range. A digital input channel identifies a sensor or a switch in two levels only – ON and OFF (0 and 1). An analog input channel enables us to read a sensor value (actually voltage) at 0-5V range.

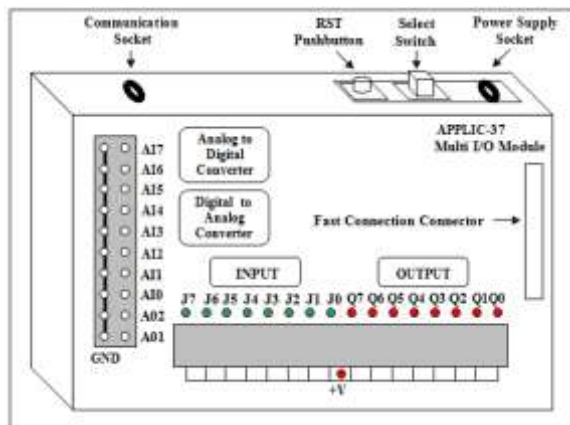


Fig 9 Pictorial View and Component Layout for applic-37

The interface performs the commands immediately and stores the program in its non-volatile memory (data in the memory is saved even after the power is OFF). The command "RUN" runs the program. When the interface receives a new program, the new program replaces the previous one stored in the memory.

5. Hydraulic Unit

The hydraulic unit comprises of the Solenoid Valve, hydraulic power unit and single acting cylinder. The connection is done below

The double acting cylinder is used in this case for the following reasons

- To achieve a swift actuation response
- To Maximise the fluid flow in retraction at limit switch pointer

- To Nomilise low-voltage output from RF input

To enable a comprehensive Design, Hydraulic System Requirements and Sizing was carried out with the following considerations

In circuit design knowing the process, the environment, machine durability in service and other items affect cylinder and power unit choices.

First is force requirement. Usually, the force to do the work is figured with a formula. In instances $F=Wg$

Secondly, choose a total cylinder stroke. Stroke length is part of machine function which enables us figure out Hydraulic pump size required.

Thirdly, how much of the stroke requires full tonnage? If only a small portion of the stroke needs full force, a HI-LO pump circuit and/or a regeneration circuit could reduce first cost and operating cost.

Fourthly, the total cylinder cycle time is required as load and unload affects part of the overall cycle time, Lastly a maximum system pressure was chosen. Since a standard hydraulic components operate at 3000 PSI maximum, a system pressure below this pressure was chosen

1. When the gate is closed.

Minimal pressure can be seen at the graph

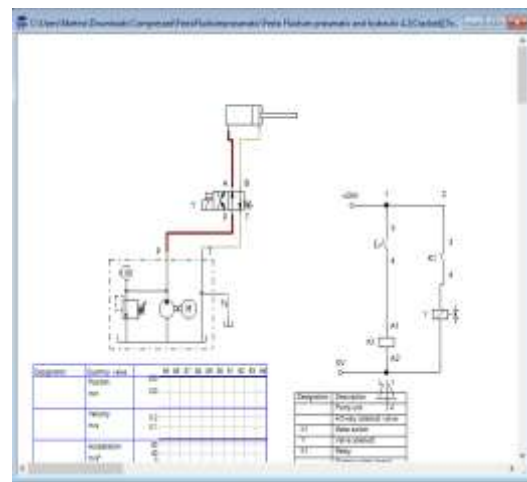


Fig. 10 Hydraulic connections for sliding door at closed stage

2. When the gate is open

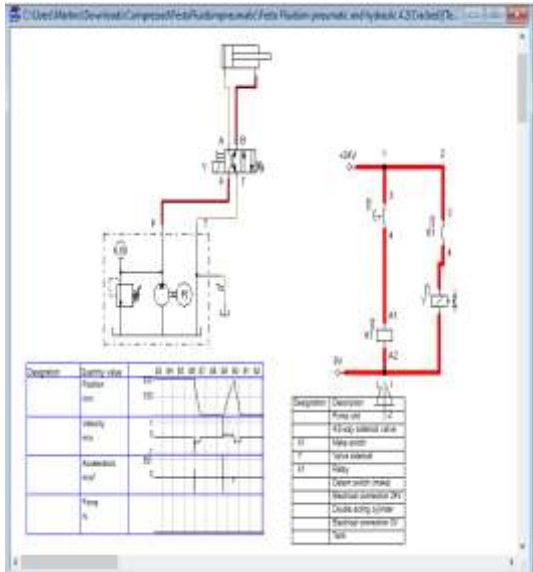


Fig. 11 Hydraulic connections for sliding door at closed stage

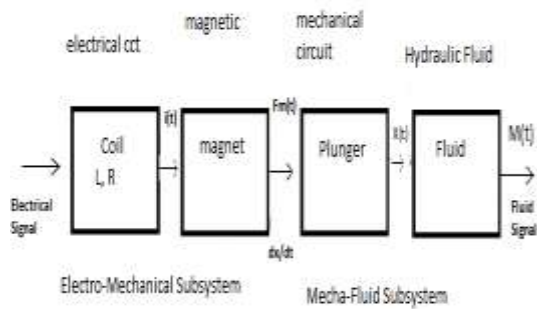


Fig 12. Solenoid Valve block Diagram

A. Electrical model

From Figure 12 above

This model represents the current passing through the coil within valve (i), in terms of the applied voltage (U_{PMM}) and the plunger position (X_p) and plunger speed (\dot{X}_p). Considering the series topology of resistance and inductance, corresponding equations are obtained as follows [1], [2]:

$$i(t) = I_p \tag{1}$$

$$U_{PMM} = R_c i(t) + L \frac{di(t)}{dt} = R_c i(t) + L \frac{d(I_p)}{dt} \tag{2}$$

$$R_c = \mu_0 \mu_r \frac{l_c}{A_c} \tag{3}$$

$$\frac{d}{dt} = \frac{U_{PMM} - R_c i(t)}{L} = \frac{U_{PMM} - R_c I_p}{L} \tag{4}$$

where: U_{PMM} applied voltage, $\phi(t)$ magnetic flux, $L(t)$ inductance of the magnetic circuit, μ_c , μ_0 core permeability and air's, μ_r relative permeability, N coil turns, l_c effective length of magnetic circuit inside the core, A_c cross-section flux and X_p the overall air gap including constant and variable values. U_{PMM} voltage, in periodic PWM signal in terms of duty cycle (D) per a period (T) is developed as follows:

$$U_{PWM} = \begin{cases} high & t \leq DT \\ low & DT < t < T \end{cases} \tag{5}$$

B. Fluid Model

The power exerted by the working fluid could be determined from the available parameters, the pressure exerted by the hydraulic pump is P, and density of the working fluid is ρ , the fluid flows with a velocity V, the enthalpy is h.

For an incompressible fluid at steady state flow between two points (1) and (2), Bernoulli equation is used to establish the energy driving the fluid, thus:

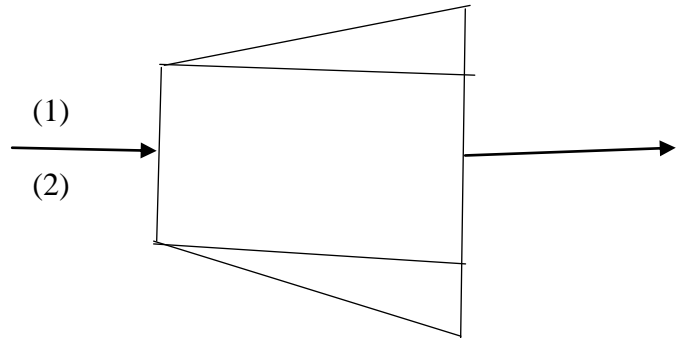


Fig 13. Flow through the Orifice

$$\frac{P_1}{\rho_1 g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho_2 g} + \frac{V_2^2}{2g} + Z_2 + h + w - q$$

Z is the elevation, w is the workdone on the fluid, while q is the heat transfer between the fluid and the environment.

Focusing our attention to the discharge of the hydraulic pump, the elevation term is negligible, the pipe is insulated, therefore the q term is also negligible.

This energy is equal to the total head of the working fluid

$E = \rho g Q H$ where E is the overall energy of the fluid, g is the acceleration due to gravity, Q is the volume flow rate, and H is the total head of the working fluid.

$$\frac{P_2}{\rho_1 g} + \frac{V^2}{2g} + H$$

Power = energy per unit time =

$$\frac{\text{weight}}{\text{unit time}} * \frac{\text{energy}}{\text{unit weight}}$$

$$\text{Power} = \rho g Q H = \rho g Q (p/\rho g + v^2/2g + z) = pQ + \frac{1}{2} \rho v^2 Q + \rho g Q z.$$

D Magnetic Model

The working fluid flowing through the piping with the power $\rho g Q H$ is controlled using a solenoid valve which acts with a force that could overcome the fluid power. The force on the solenoid valve has been established thus: This calculator computes the force between a solenoid and another piece of

ferromagnetic material separated by a gap of distance g .

$$F = (Fm)^2 \mu_0 A / (2g^2)$$

$$F = (N \cdot I)^2 \mu_0 A / (2g^2),$$

Where:

- $\mu_0 = 4\pi \times 10^{-7}$
- F is the force in Newtons
- N is the number of turns
- I is the current in Amps
- A is the area in length units squared
- g is the length of the gap between the solenoid and a piece of metal.

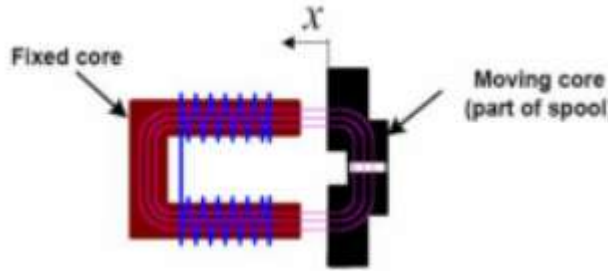


Fig 8 Magnetic Circuit

E. Cylinder Model

The force produced by a double acting hydraulic piston on the rod side can be expressed as

$$F_1 = (\pi (d_2^2 - d_1^2) / 4) P_1 \quad (1)$$

where

F_1 = rod pull force (lb, N)

d_1 = rod diameter (in, m)

d_2 = piston diameter (in, m)

P_1 = pressure in the cylinder (rod side) (lbf/in² (psi), N/m² (Pa))

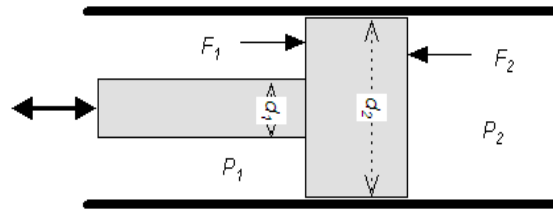
The force produced opposite the rod can be expressed as

$$F_2 = (\pi d_2^2 / 4) P_2 \quad (2)$$

where

F_2 = rod push force (lb, N)

P_2 = pressure in the cylinder (opposite rod) (lbf/in² (psi), N/m² (Pa))



4.0 Testing and Results

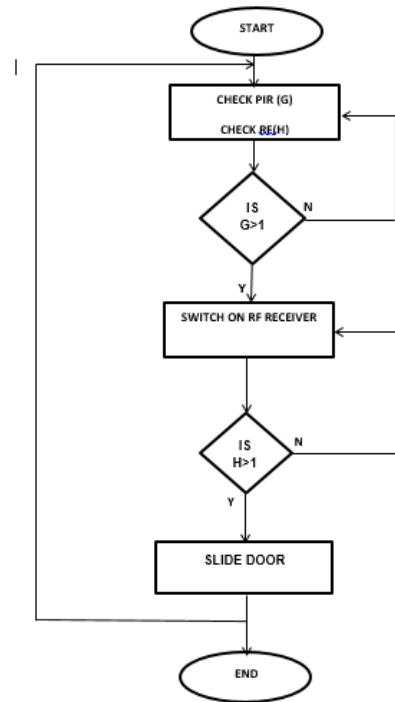
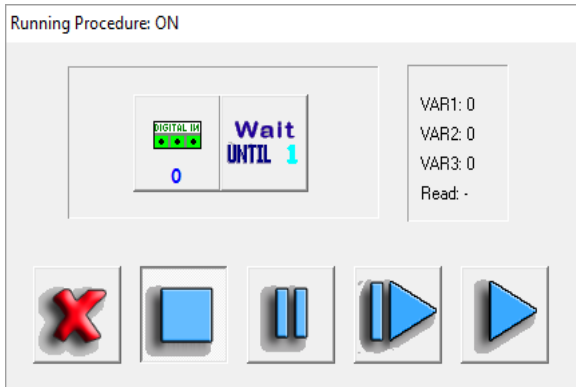


Fig 14. ssGate Algorithm Flow Chart





Result of Pressure and RF Effect on the system

Designation	Quantity	value	529	530	531	532	533	534	535	536	537	538
Position mm		200										
		100										
Velocity m/s		0.2										
		0.1										
		0										
Acceleration m/s ²		80										
		40										
		0										
Force N												

Fig 16 program and simulation when gate is closed



Result of Pressure and RF Effect on the system

Designation	Quantity	value	656	657	658	659	660	661	662	663	664	665
Position mm		200										
		100										
Velocity m/s		1										
		0										
		-1										
Acceleration m/s ²		581										
		0										
Force N												

Fig 14 Program and simulation when gate is opened.

5.0 CONCLUSION

Unlike the other automation systems used for outer gates the proposed system has a very precise operation, composite operation devoid of errors and can block the opening or the closing of the gate. The delays, provided in the program, are carefully calculated to be more useful in the practical operation of these systems. Benefits of the microcontroller Applic-37 are used efficiently and the simplicity of the structure makes this system be easily modified and improved. It has earlier analogue and digital sensing capabilities.

6.0 REFERENCES

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