Proto Modeling of Liquid Level Controller.

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ABSTRACT: In this article, a simple liquid level control system design approach has been discussed. The system makes use of three electrode arrangement to introduce hysteresis in the control which is necessary to protect the motor. The circuit makes use of IC NE555 as a RS flip-flop which controls switching of motor. The system has been thoroughly tested and works fine for different liquid levels. The MATLAB simulation has also been used as a virtual design approach and the results have been proved by the simulation.

Key Words- Liquid level, NE555, MATLAB Simulator, RS Flip-flop, Controller

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1 INTRODUCTION

When a control system has to be developed one can find many solutions for the problem, viz. simple on-off control, more sophisticated and smoother proportional (P), proportional-integral (PI), proportional-derivative (PD) and the combination of the three proportional-integral-derivative (PID)[1,2,3]. Each of these control algorithms has its own advantages and limitations. While the PID algorithm is more close to ideal solution, its design complexity makes it avoidable for many applications. On the other hand, the two

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Position on-off control[1,2] is preferred for its simplicity when the application requirements are not much substantive.

When the on-off type of control has to be adopted, it must be incorporated with the proper dead-band. If the hysteresis is too low, the control element may get damaged because of rapid switching between on-off states when the set-point has approached. On the other hand if the hysteresis is too high the system may become too sluggish and introduces large magnitude errors. Thus it is important to devise proper algorithm for the calculation of hysteresis.

The liquid level controller[2,3] discussed in this paper is an ON/OFF with hysteresis. It has been designed with IC 5554 used as RS flip-flop with hysteresis. The hysteresis characteristic of ON/OFF control has been introduced by means of two sensing electrodes configured as middle and upper electrode; and a reference electrode. This arrangement avoids a sudden on/off action of motor and consequent motor damage.

C.V Le[7] et al have presented a simulation model of an oil-injected screw liquid chiller, where the refrigerant shell and tube heat exchangers are modeled following local heat transfer integration approach. All major components of the system are modeled in a modular format such as an oil-injected screw compressor, a shell and tube condenser, a flooded evaporator, and a high side-float valve.

Antoine McNamara [8] et al has described a novel method for controlling physics-based simulations through gradient-based nonlinear optimization. Using a technique known as the *ad joint method*, derivatives have been computed efficiently, even for large 3D simulations with millions of control parameters.

2. WORKING

The proposed circuit used to control the liquid level is shown in fig. 1. In this design AC sensing circuit has been used rather than the DC. The AC sensing avoids the deposition problem. AC 50V/50Hz signal derived with step down transformer from the mains supply has been passed in liquid through bottom electrode. The AC source supply is passed through the isolation transformers (T1-T4) to provide the isolation between the control circuit and the mains supply. The remaining two electrodes (upper and middle) are used to

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detect the water levels in the respective tanks. The non corrosive electrodes (steel made) have been placed at preset liquid levels. As the liquid level rises/falls, AC voltage gets applied to the half wave rectifier through the conducting path. The rectifier stage has been followed with voltage doublers. This voltage generates the trigger signal to the IC555.The IC 555 are designed in RS flip-flop mode. The high voltage at pin no. 2 sets the output of IC 555 and high at pin no. 6 resets the output of IC 555.The sensing levels of upper tank are supplied to IC 555(1) and the sensing levels from the lower tank are applied to the IC555(2).The output from the IC 555(1) is inverted and is ANDed with output of IC 555(2) so as to get proper logic function of the whole system.The INVERTed logic and ANDing are designed with CMOS NAND gate 4017(5) The ANDed output drives the relay driver circuit .The relay driver connects the Mains supply to the Motor or disconnects it from the Motor depending upon the drive condiction.The drive condition has been considered to be TRUE for the following situations: lower tank is full and upper tank is empty or partially empty; and FALSE for all other conditions. Table 1 gives the logic of the system operation.

The TRUE condition turns on the relay through relay driving transistor. The AC motor has been connected to AC mains through NO mode of relay. Thus when the condition is TRUE the motor turns on and remains ON until the condition is TRUE i.e till the liquid level is below the upper electrode of upper tank.

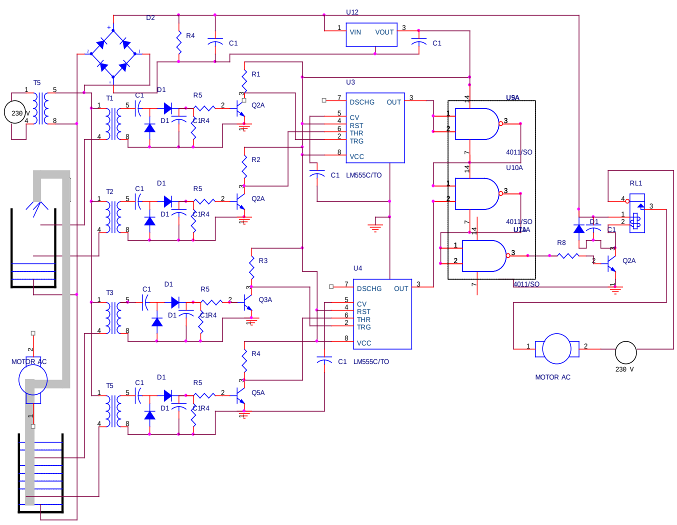

Fig.1. Circuit diagram

3 SIMULATION MODEL

The main simulation model for the liquid level control system designed with the simulink toolbox of MATLAB[6] is shown in fig. 2. The Main simulation model is explained with 1) Simulation model for upper tank logic level converter 2) Simulation model for lower tank logic level converter and turn ON/OFF MOTOR circuit.

In the main simulation model the liquid levels in upper and lower tanks have been represented by constants. The presence of liquid at the sensing electrode has been represented by logic '1' and absence of liquid by logic '0'. The detailed functioning of each simulation model are explained with the models shown by fig. 3 to fig 7.

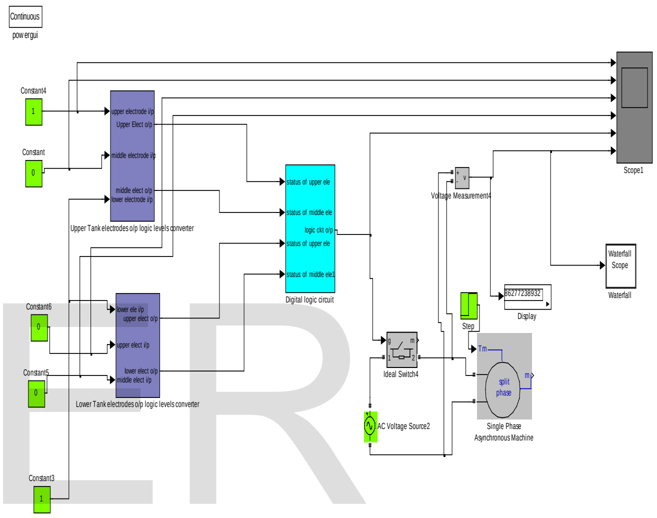

Fig. 2 Main Simulation model for liquid level controller

In the simulation model for upper tank logic level converter shown in fig.3. the status of upper and middle electrodes of upper tank are compared with the status of lower electrode by using subs tractor block and compare block.The logic low level on the electrodes indicate that the tank is empty and logic high level indicates the tank is full.When the upper and middle electrodes are set to zero that is upper tank is empty then the compare to zero2 block output sets to logic zero state AND and compare to zero1 block output sets to logic one state.

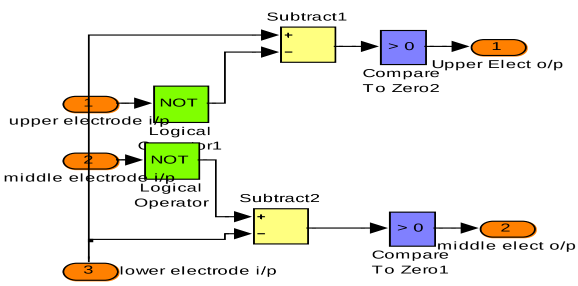

Fig.3 Simulation model for upper tank logic level converter

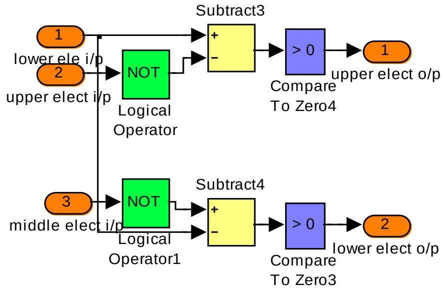

Fig.4 Simulation model for lower tank logic level converter

In the simulation model for lower tank logic level converter shown in fig.4. the status of upper and middle electrodes of lower tank are compared with the status of lower electrode by using subs tractor block and compare block. The logic low level on the electrodes indicates that the tank is empty and logic high level indicates the tank is full. When the upper and middle electrodes are set to one that is lower tank is full then the compare to zero4 block output sets to logic one state and compare to zero3 block output sets to logic low state.These states of upper tank and lower tank are used to set or reset the S-R flipflops as shown in fig.5.

Pin. No.2 of 555	Pin no. 6 of 555	Output of IC 555(1)	Pin. No.2 of 555	Pin no. 6 of 555	Output of IC 555(2)	Motor status
0	0	0	1	1	1	Motor ON
0	1	0	0	1	1	Motor ON
1	1	1	0	0	0	Motor OFF
For all other states	For all other states	1	For all other states	For all other states	0	Motor OFF

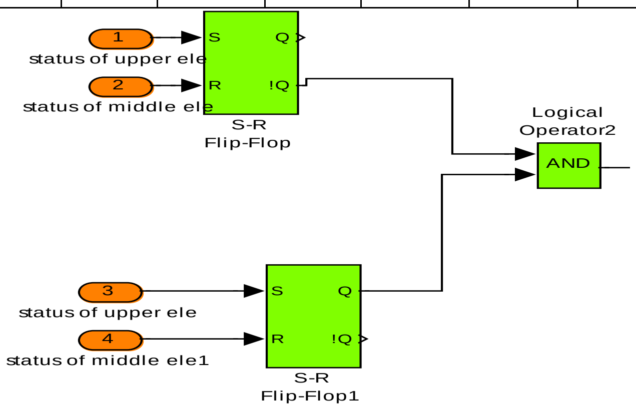

Fig.5 Simulation model for digital logic level converter to turn ON/OFF MOTOR

For upper tank empty the flipflop output(Q!) sets to logic high and for lower tank full the flipflop1 output sets to logic high. ANDing of these two states is used to drive the relay driver cicuit and depending on the out of AND gate the motor is turned ON or OFF.

The detailed simulation model is as shown in fig.6 the results of practically observed circuit are tabulated in table1.In table 1 the states specified at pin no.2 and 6 are inverted states of actual states of electrodes. The hysteresis in the system is important to avoid the chattering and sudden turn on or off of motor. It is introduced by using the three electrodes in each tank as shown. The lower electrode acts as a source electrode, while remaining two that is middle and upper electrodes are the sensing electrodes. Practically the water level between two electrodes(upper and middle) is hysteresis .This is shown in fig.7.

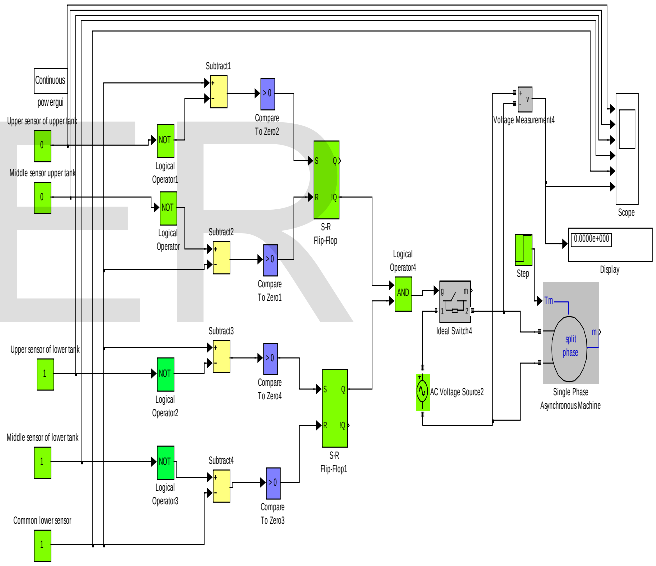

Fig.6. Detailed Simulation model water level controller

Table 1. Truth table for the system operation

Lower Tank **Upper Tank**

1---Empty liquid state of tanks

0---Full liquid state

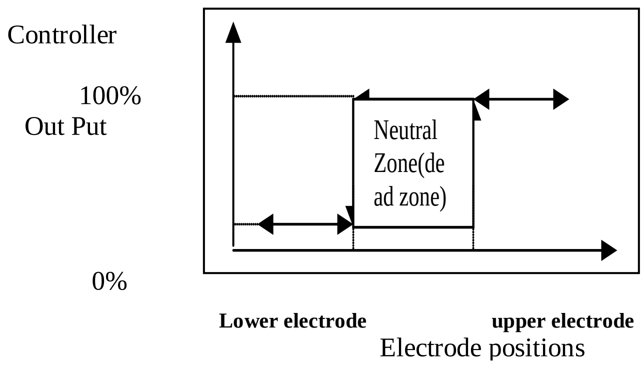

Fig.7. Hysteresis loop

4. RESULT

The fig. 8 shows simulation results for the valid condition, i.e. when the lower tank is full and upper tank is empty.

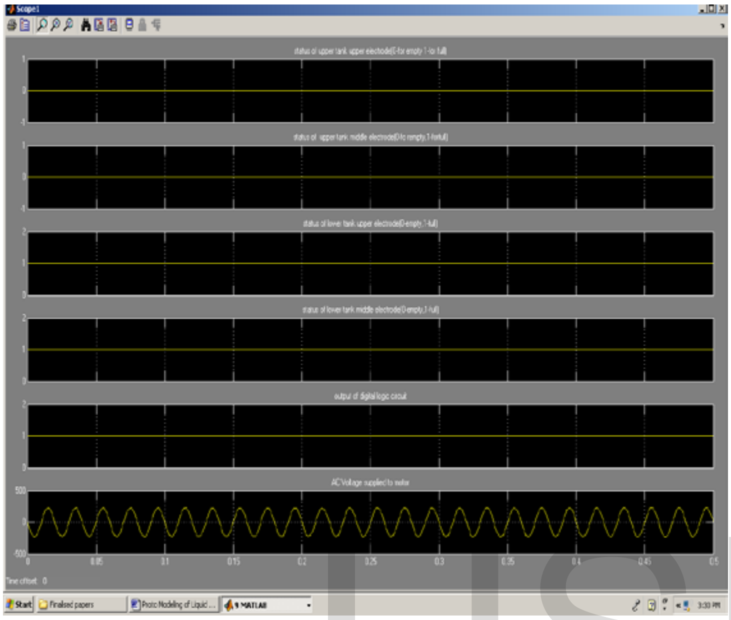

Fig.8. Simulation model results

5. CONCLUSION

In this work the sensor degradation because of deposition and deterioration has been minimized by means of AC sensing mechanism. The use of three electrode arrangement effectively eliminates the sudden switching of motor. Thus the resulting system has been found to be quite simple but still effective solution for liquid level control applications.

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