

# Design and Analysis of Adaptive Neuro Fuzzy Logic Controlled Wireless Intelligent Telemetry System

Rajwinder Kaur

Department of Computer Science and Engineering,  
Baba Banda Singh Bahadur Engineering College,  
Fatehgarh Sahib, Punjab, India

Kanwalvir Singh Dhindsa

Department of Computer Science and Engineering,  
Baba Banda Singh Bahadur Engineering College,  
Fatehgarh Sahib, Punjab, India

---

**Abstract**— Telemetry systems is an innovative design of electronics and computer system which can be used to take measurements from a remote site by using any type of link like Radio link, optical fiber, co-axial cables etc. Telemetry systems can take any of the measurement like pressure, temperature, density, humidity etc. from a target location and sends the taken measurements via wired or wireless links that may be sent over few meters or may be sent over wide range. There are great and flawless changes in various telemetry systems from some past years that brought a nice popularity to use these systems rather than keeping a human eye on measurements. Telemetry systems have made a user free from taking measurements at target site, noting down the readings, turning the machines on or off. In this paper adaptive neuro fuzzy Logic is combined with wireless telemetry systems to control water flow in water/any fluid Tank used in industries.

This paper presents the design of a wireless telemetry system for controlling the flow of water in water tanks used in industrial process using adaptive neuro fuzzy logic called adaptive neuro fuzzy inference system. To incorporate artificial intelligence basically fuzzy logic and artificial networks are used. In this research these two models are initially studied. The advantages and disadvantages of both are discussed. Then these two models are compared by taking different parameters. By combining positive measures of fuzzy logic and artificial neural network, adaptive neuro fuzzy logic is considered as better method to incorporate artificial intelligence in the present research work. The resultant system is an assemblage of computer and communication equipments designed to work together for the purpose of measuring and controlling the flow of water in water tanks (tanks may contain any liquid) placed at far side. Besides control, The systems performs monitoring, data logging, alarming and diagnostic functions so that large, complicated process systems can be operated in a safe manner and maintained by a relatively small staff or just by a computer.

**Keywords**- fuzzy logic; artificial neural networks; adaptive neuro fuzzy inference system; telemetry system; adaptive neuro fuzzy logic.

---

## I. INTRODUCTION

Software systems incorporating artificial Intelligence have shown many advantages in engineering system control & modeling [8]. Artificial neural networks (ANN) and Fuzzy logic are two main branches of artificial Intelligence. While the former has the capability of learning by means of parallel connected units, called neurons, which process inputs in accordance with their adaptable weights usually in a recursive manner for approximation; the latter can handle imperfect information through linguistic variables, which are arguments of their corresponding membership functions. Operating with linguistic expressions, fuzzy logic can use the experiences of a human expert and also compensate for inadequate and uncertain knowledge about the system. On the other hand, ANNs have proven superior learning and generalizing

capabilities even on completely unknown systems that can only be described by its input-output characteristics[3][10]. Fuzzy logic and ANN are complementary technologies in the intelligent systems. The combination of these technologies is a best way to develop an intelligent system. These two approaches can design an intelligent system in different ways. ANN are essentially low level, computational algorithms that offer a good performance in control tasks, where Fuzzy logic provides a structural framework that uses these low level capabilities of ANN.

Table 1 shows a comparison of these two technologies. It is obvious from the Table 1 that combination of these two technologies delivers the best technology for intelligent systems.

The resulting system with the combination of both Fuzzy Logic and ANN will have the advantages of both these

technologies. In this way, it is possible to bring the low level learning and computational power of ANN into fuzzy system and high level humanlike IF-THEN thinking and reasoning of fuzzy systems into artificial neural networks [10]. Thus the resulting approach is Adaptive Neuro Fuzzy Inference system (ANFIS).

TABLE 1: COMPARISONS OF FUZZY LOGIC AND NEURAL NETWORKS

S.no	Parameters	Fuzzy Logic	Neural Networks
1.	Trainability	No trainability, everything must be defined explicitly	Can train itself by learning from given data set
2.	Knowledge representation	Knowledge representation is explicit	Knowledge representation is implicit
3.	Verification	Verification and optimization is easy and efficient	The system can not be easily modified or interoperated
4.	Decision making	Good decision makers	Decision is taken on past experiences
5.	Learning capability	Good learner	Slow learner constantly learning from trial & error
6.	Supervision of work	Not so good at supervision of work	Good at supervision of work as this work becomes best from
7.	Problem Solving	Problem solving using mathematical modelling	tries to incorporate human thinking process to solve problems

Adaptive neuro fuzzy logic a network which uses learning capability of neural network to enhance the performance of the system using prior knowledge. ANFIS is an adaptive network. An adaptive network is network of nodes and directional links. It's called adaptive because some, or all, of the nodes have parameters which affect the output of the node. These networks are learning a relationship between inputs and outputs. There is always a learning rule associated with the network. The ANFIS approach learns the rules and membership functions from data [11].

“Telemetry” means distant measurement of something which is measurable. For example, in industrial process to check water level in water tank, oil level in oil tank or some other kind of level checking without going on measuring site, and to get results on handheld device or computer system, then undoubtedly an effective telemetry system is chosen for ease. In telemetry systems, the measurements can be monitored or status can be received about running measurements at distant sites. For instance, a manager of Fuel Company can see the fill level and deduction level of fuel from a particular tanker while sitting in his cabin or office at his laptop. Telemetry systems has advanced the field of electronics and computers and provided a greater ease to workers regarding measurements. Telemetry informs about measurements via radio waves or IP

network transmission and reception of the information, or it can make use of serial communication. Although the term commonly refers to wireless data transfer mechanisms (e.g. using radio, hypersonic or infrared systems), it also encompasses data transferred over other media such as a telephone or computer network, optical link or other wired communications like phase line carriers. Many modern telemetry systems take advantage of the low cost and ubiquity of Global systems for Mobile communications (GSM) networks by using SMS to receive and transmit telemetry data.

## II. PROPOSED WORK

### A. Proposed Block Diagram

Telemetry has been widely used to measure the fluid levels in industries, factories where a small amount of fluid measurement is crucial. Various sensors have been employed in telemetry systems to sense the fill level and the information of sensors has been fed to some programmed systems for further processing of data and for decision making rules. The proposed system will take the measurements of fluid levels by installed sensors in fluid storing tank. When fluid level touches the sensors, an appropriate electrical signal will be sent to microprocessor installed on remote site. It will trigger RF encoder to modulate this signal and will transmit information via RF transmitter. Likewise, there will be three sensors installed in tanks to make it three tier sensing mechanism. Sent out signals will be received by RF receiver that will be connected to other microprocessor via RF decoder at recording and display end, which will be connected to computer system's serial via RS-232 interface to send the measured data or information into computer system to display measurement in form of bars and to record measured data in computer's database. On the other hand, at computer's side, when one bar will show a level of 100% filling of associated tank to it, it will prompt the user to shut the associated machinery down automatically or manually. As per user's choice, computer system reacts either intelligibly or on manual actions. It then starts sending the signals out from the computer system to shut off the associated machinery of particular tank. These signals are brought to microprocessor connected outside the computer via RS-232, and will be transmitted to remote site controlling circuits via Radio encoders and RF transmitters. The proposed block diagram explaining the methodology is shown in Figure 1.

### B. Hardware Unit

Initially the logic design of the system has been prepared. Basically the proposed system incorporates both hardware and software elements. Hardware consists of 8051 microcontroller, Power supply units, water level reading units, RF encoders and RF decoders, RS-232 interface. The proposed telemetry system work consists of two hardware units. One transmitter unit and other is receiver unit.

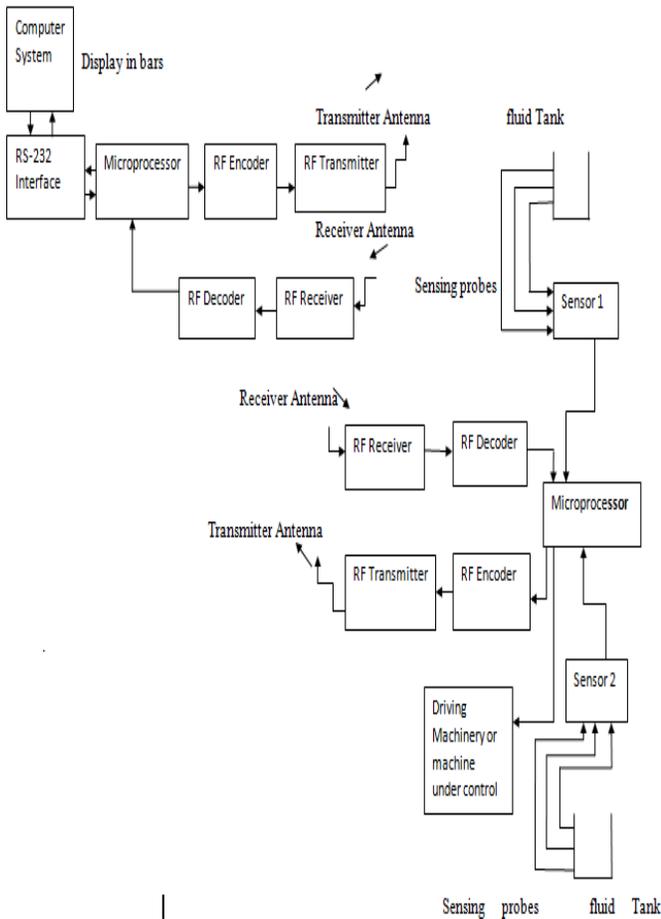


Figure1. Proposed Block Diagram of Computer based Wireless Intelligent Telemetry system

C. Transmitter Unit

The transmitter unit contains AT89S51 processor .The circuit diagram of Transmitter end is shown in figure 2.

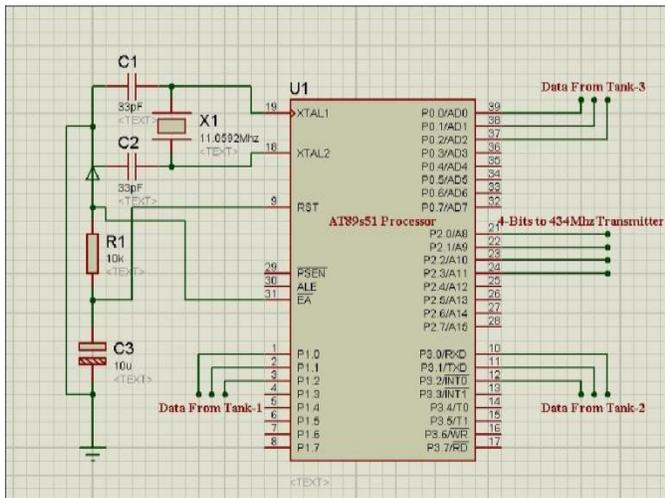


Figure 2. Circuit Diagram of transmitter unit.

Transmitter unit consists of

- Power supply unit
- Three tanks
- Water level readers
- At89S51 processor
- 434 MHz Transmitter with antenna

Initially Transmitter unit has been connected to power supply. The Power supply unit of transmitter unit consists of one step down transformer which converts 230 AC voltage to 12 AC Voltage. The four diodes and one capacitor placed on power supply unit converts 12 AC voltage to 12 Dc Voltage. The regulator placed on same unit converts 12 DC voltages to 5 DC voltages because +5 V is needed to provide power to 8051 processor. Three tanks can be filled with water simultaneously or one by one. A water level reader circuit has been attached to these three tanks. There has been three transistors and nine resistors used particularly for one tank. Thus for three tanks total 9 transistors and 27 resistors has been used on water level reader circuit. This circuit sends signals to AT89S51 processor about four levels of tanks (Empty, Low, Medium and High).

On getting signals from water level circuit, the processor generates hex codes as shown in Table 2.Processor includes Power On Reset circuit consisting of one capacitor and one resistor and tank circuit(Oscillation circuit) consisting of one quartz crystal and two capacitors .

Hex codes generated by processor AT89S51 has been sent to Transmitter circuit which includes 4 bit 434 MHz transmitter which sends the hex codes generated by Processor to the receiver side for further processing. It also includes one bit receiver which receives the signal from receiver side to shut down the particular motor of completely filled water Tank.

D. The Receiver Unit

Receiver unit contains AT89S51 processor, RS232 interface to communicate with computer and three LEDs as indicators for three tanks as shown in figure 3.

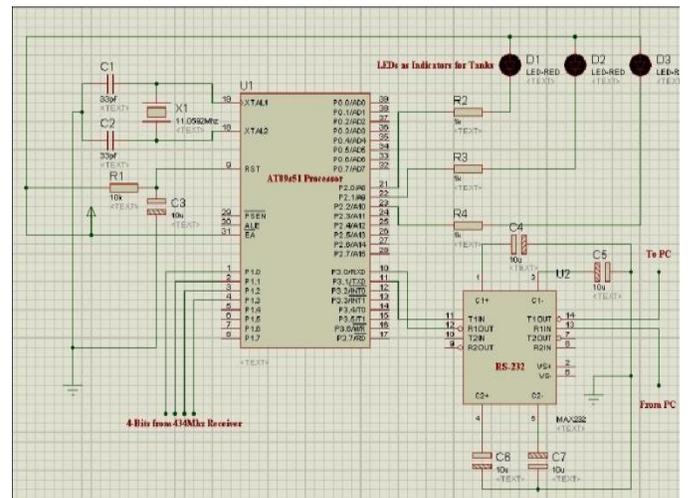


Figure 3. Circuit Diagram of Receiver unit.

Receiver unit basically consists of 4 subunits described as follows:

- Power supply unit
- AT89S51 Processor
- 434 MHz Receiver
- RS-232 Interface unit

The hex codes generated by transmitter side have been received by 434 MHz receiver, which sends these codes to the processor placed at the receiver side. The processor generates appropriate codes as shown in Table 2 and sends these codes to computer system using RS-232 interface which serially sends these codes to computer system for displaying the levels of tanks and takes signal from computer system to shut down the motor associated with completely filled tank.

### III. IMPLEMENTATION

The system is using different hex Codes corresponding to different levels of three tanks under consideration as shown below in Table 2. Table shows four levels of each tank:

- Empty: When there is no water in Particular tank
- Low level: When water first touches the lowest sensor located at the bottom of tank
- Medium level: When second sensor touches the water placed at the half height of the tank
- High Level: When third sensor touches the water placed at the top of the water tank

Hex codes are generated by the processor placed at the transmitter side to provide information regarding different levels of tanks to the processor at the receiver side. This processor sends signals in the forms of ASCII codes as shown in Table 2 to the computer through RS-232 interface using serial communication at 9600 bauds/sec.

TABLE 2: HEX CODES AND ASCII CODES CORRESPONDING TO DIFFERENT LEVELS OF THREE TANKS

Tank No.	Levels	Hex Codes generated at Transmitter side	Hex Codes received at the receiver side	ASCII codes sent to computer by receiver side
Tank A	Empty	0A	FA	D
Tank A	Low	01	F1	A
Tank A	Medium	02	F2	B
Tank A	High	03	F3	C
Tank B	Empty	0B	FB	H
Tank B	Low	04	F4	E
Tank B	Medium	05	F5	F
Tank B	High	06	F6	G
Tank C	Empty	0C	FC	L
Tank C	Low	07	F7	I
Tank C	Medium	08	F8	J
Tank C	High	09	F9	K

At transmitter side three ports P0,P1, P3 of each 8 bits are taken as input ports and One port P2 of 8-bit is used as output port. Initially each input port reads FF where all 8 bits are

1. thus initially each tank is empty. At low level of each tank the least significant bit of 8 bit port becomes 0. At Medium level two least significant bits of 8 bit port becomes 0 and at high level of each water tank last three least significant bits of 8 bit port becomes 0. The corresponding bit patterns of different levels of tanks are shown in Table 3.

TABLE 3: HEX CODES AND CORRESPONDING BIT PATTERNS OF INPUT PORTS OF DIFFERENT LEVELS OF TANK

Levels of Tank	Hex Codes	Bit Pattern
Empty	FF	11111111
Low	FE	11111110
Medium	FC	11111100
High	F8	11111000

#### A. Algorithm at Transmission Side

Input: three ports P<sub>0</sub>, P<sub>1</sub>, P<sub>3</sub>

Output: One port P<sub>2</sub>

1. initially all three input ports are equal to FF.
2. If P<sub>0</sub> == FF then P<sub>2</sub> = 0A (tank A is empty)  
 Else if P<sub>0</sub> <> FF then  
 {  
   If P<sub>0</sub> == FE then P<sub>2</sub> == 01 (level of tank A is low)  
   If P<sub>0</sub> == FC then P<sub>2</sub> == 02 (level of tank A is medium)  
   If P<sub>0</sub> == F8 then P<sub>2</sub> == 03 (level of tank A is High)  
 }
3. Else if P<sub>1</sub> == FF then P<sub>2</sub> = 0B (tank B is empty)  
 Else if P<sub>1</sub> <> FF then  
 {  
   If P<sub>1</sub> == FE then P<sub>2</sub> == 04 (level of tank B is low)  
   If P<sub>1</sub> == FC then P<sub>2</sub> == 05 (level of tank B is medium)  
   If P<sub>1</sub> == F8 then P<sub>2</sub> == 06 (level of tank B is high)  
 }
4. Else If P<sub>3</sub> == FF then P<sub>2</sub> = 0C (tank C is empty)  
 Else if P<sub>3</sub> <> FF then  
 {  
   If P<sub>3</sub> == FE then P<sub>2</sub> == 07 (level of tank C is low)  
   If P<sub>3</sub> == FC then P<sub>2</sub> == 08 (level of tank C is medium)  
   If P<sub>3</sub> == F8 then P<sub>2</sub> == 09 (level of tank C is high)  
 }  
 Else "wrong choice"

#### B. Algorithm at Receiver side

Input: single port P<sub>2</sub>

- If P<sub>2</sub> == FA then send "D" to computer  
 Else if P<sub>2</sub> == F1 then send "A" to computer  
 Else if P<sub>2</sub> == F2 then send "B" to computer  
 Else if P<sub>2</sub> == F3 then send "C" to computer  
 Else if P<sub>2</sub> == FB then send "H" to computer  
 Else if P<sub>2</sub> == F4 then send "E" to computer  
 Else if P<sub>2</sub> == F5 then send "F" to computer  
 Else if P<sub>2</sub> == F6 then send "G" to computer  
 Else if P<sub>2</sub> == FC then send "L" to computer  
 Else if P<sub>2</sub> == F7 then send "I" to computer  
 Else if P<sub>2</sub> == F8 then send "J" to computer

Else if  $P_2 == F9$  then send “K” to computer  
 Else send “M” to computer (M means no signal received by the receiver from transmitter)

RESULTS AND DISCUSSIONS

The receiver side of the telemetry system is attached with computer to get the output of the system .As discussed earlier four levels of each tank are considered as follows:

- Full level(Large)
- Half level(Medium)
- Low level
- Empty

Corresponding percentage of different levels of water tanks is tabulated in Table 4.

TABLE 4: CORRESPONDING PERCENTAGE OF DIFFERENT LEVELS OF WATER TANK

Tank	Water /Fluid %age
Empty	0
Low	33.33
Medium	66.66
Large	99.99

The graphical representation of Table 4 is shown in figure 4.

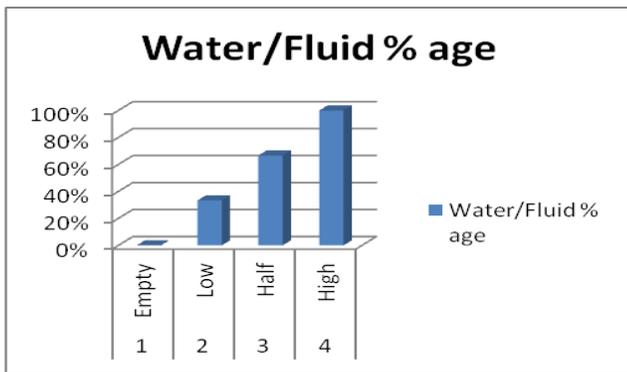


Figure 4. Graphical representation of percentage of water of different levels of tanks.

The Present system has taken six ports of the computer system to connect telemetry system to computer system so that the computer can show real time filling of water tanks showing different levels of water tanks. Any port number can be selected from six ports as shown in Figure 5.

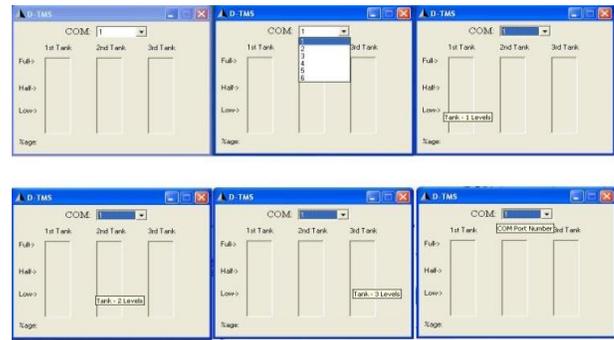


Figure 5. Graphic Display of port selection

The computer can display levels of three tanks simultaneously. Figure 6 shows the various scenarios as listed below:

- Port number 1 is selected
- Second tank is filled up to low level (33.33%)
- Third tank is also filled up to low level (33.33%)
- Second tank is filled up to half level (66.66%) and third tank is at previous level (33.33%)
- Second tank is filled up to Full level (99.99%) and third tank is at previous level (33.33%)
- Second Tank is empty (0%) and third tank is at previous level (33.33%)

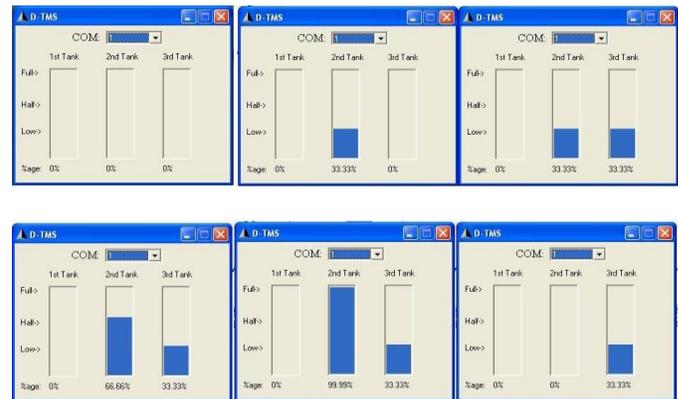


Figure 6. Graphic Display of various levels of tanks.

The system is using three LEDs at the site where water tanks are placed, which are used in place of quite bulky motors which can be turned ON or OFF according to the levels of Tanks. When a tank is half filled, the respective LED/motor remains ON so that tank can be further filled with water. When the tank is fully filled with water, the corresponding motor should be turned off to stop the overflow of tank so respective LED is turned off in our system. The corresponding logic levels are considered. Logic level 1 corresponds to ON LED and logic level 0 corresponds to OFF LED. Table 5 shows the status of LEDs according to the different levels of tanks.

TABLE 5. STATUS OF LEDS OF RESPECTIVE TANK LEVELS

Tank level	LED/Motor	Logic levels
Empty	ON	1
Low	ON	1
Half(Medium)	ON	1
Full(High)	OFF	0

The graphical representation of status of LEDs/motors corresponding to different levels of tanks is shown in figure 7.

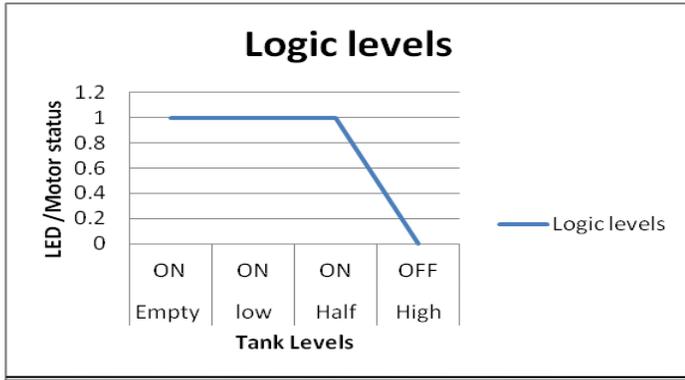


Figure 7. Status of LEDs/Motors of respective tank levels.

#### IV. CONCLUSION

In this paper, design of wireless telemetry system for controlling water flow in water tanks used in industrial process is presented using portable demo design of the system. Two hardware units one Transmitter unit connected to water tanks and other receiver unit which is connected to computer are designed using AT89S51 processor. The programming using ANFIS logic is performed using KEIL micro vision 4 and embedded C. Algorithms used at transmitter side and receiver side are also presented. Before actual implementation logical design is tested on Proteus\_v7.8i .For further enhancements in the current design we can add GSM module in the current programming to control the flow of water in tanks using mobile phones which may be connected to the computer placed the receiver side .The speed of water flowing into the tanks can also be measured by using rotary mechanism with light sensors in the water pipe. Electronic valves can also be used at individual tanks which can be controlled by the computer. In that case only one motor (for filling up the tanks with water) is required instead of using individual motor for individual tank.

#### REFERENCES

- [1] Ali Y.M., Zhang L., "A methodology for fuzzy modeling of engineering systems", Fuzzy Sets and Systems, pp.181-197, 2001.
- [2] Alvisi S., Mascellani G., Franchini M., and B'ardossy A., "Water level forecasting through fuzzy logic and artificial neural network approaches", Hydrology and Earth System Sciences, 10, pp. 1-17, 2006.
- [3] Atmaca,H., Cetişli, B., and Yavuz ,H. Serhan, "The comparison of Fuzzy Inference Systems and Neural Network approaches with ANFIS Method for Fuel Consumption", International Journal of Engineering, 2010.
- [4] Canuto,M.P., "Combining neural networks and fuzzy logic for applications in character recognition", Ph.D. Thesis, University of Kent, Canterbury Electronic Engineering Department, p.p 2-16, 2001.
- [5] Gardner, Alan T., Karam, Hanan N. , Mulligan,Ann E.,Harvey Charles F., Hama, Terence R.and Hemond, Harold F., "A Differential Pressure Instrument with Wireless Telemetry for In-Situ measurement of Fluid Flow across Sediment-Water Boundaries", Sensors, pp. 404-429, 2009.
- [6] Harper,G., Edgar, A., Fossà, A., Finley, D., and Strang,G., "Advanced Acoustic Telemetry System Provides Real-time Data Acquisition that Increases Efficiency in Well Testing Operations", Offshore Technology Conference , Houston, Texas, U.S.A, 2003.
- [7] Kim,T.K., and Seo H.S., "A Trust Model using Fuzzy Logic in Wireless Sensor Network", World Academy of Science,engineering and Technology, 2008.
- [9] Lee S.H., Howlett R.J., Walters S.D., and Crua,C, "Fuzzy Logic and Neuro-fuzzy Modelling of Diesel Spray Penetration," Journal of Intelligent and Fuzzy Systems, Volume 18, pp. 43-56, 2007.
- [10] Malhotra R., Singh,N., Singh Y., "Fuzzy Logic Modelling, Simulation and Control: A Review", International Journal of ComputeScience and Technology, pp. 183-188, 2010.
- [11] Mayilvaganan, M.K., Naidu, K.B., "ANN and Fuzzy Logic Models for the Prediction of groundwater level of a Watershed", International Journal on Computer Science and Engineering ,Vol. 3, pp. 23-30, 2011.
- [12] Mote,T.P.,Dr.Lokhande,S.D., "Temperature Control System Using ANFIS",International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Vol. 2, Issue-1, 2012.
- [13] Musteric, Steven A., and Berdugo, A., "The Advanced Subminiature Telemetry System (ASMT): A Wireless, Non-Intrusive, Network Based, Instrumentation System",2007 Test Instrumentation Workshop, Ridgecrest, CA, 2007.
- [14] Nayak ,P.C., Sudheer K.P., Rangan D.M., Ramasastri K.S., "A neuro-fuzzy computing technique for modeling hydrological time series", Journal of Hydrology , pp. 52-66, 2004.
- [15] Obeid, I. , Nicolelis ,Miguel A.L. , Wolf,Patrick D., "A multichannel telemetry system for single unit neural recordings", Journal of Neuroscience Methods , pp. 33-38, 2004.
- [16] Tayfur ,G., Singh ,Vijay P., "ANN and Fuzzy Logic Models for Simulating Event-Based Rainfall-Runoff", Journal of Hydraulic Engineering , pp. 21-30,2006.
- [17] Trent, Andy, "Remote Telemetry System for Particulate Monitoring", States Department of Agriculture Forest Service, 2002.
- [18] Wu, D., Karray,F., Song ,I., "Water Level Control by Fuzzy Logic and Neural Networks," IEEE Conference on Control Applications, 2005.