Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

Gate Control Mechanism for Water Discharge at Canal

Prof. Sunil. R. Hirekhan
Saurabh Pandit
Dept. of Electronics and Telecommunication Engg.
Govt. College of Engineering, Aurangabad

***Abstract*—Traditionally, water discharge at canals is operated manually using local upstream control. Usually, the water discharge is implemented as per a pre-specified schedule which is fixed. Hence, the discharge from the upstream is unresponsive to the requirements of downstream demands, may result in an inefficient use of an invaluable resource. The gate control mechanism for water discharge at canals is an automated, accurate model for efficient water use. The system accepts the Quantity of water to be discharged, takes into account the upstream water levels, controls the microcontroller based induction motor circuit and operates the opening and closing of the canal gate, to allow requisite quantity of water to be released. The system is implemented using LabVIEW platform , which provides proper graphical user interface and precise control.**

Keywords— Gate Control, Phase Angle Control, Graphical User Interface,Water Discharge

I INTRODUCTION

The adequate utilization of the natural resources like, water is a must, and appropriate systems are needed in place in order to conserve the same. It is observed that , traditionally, the canals are operated manually, using the local upstream control, and water is discharged according to the pre-specified schedule before a crop season, which is usually fixed. A delivery schedule is the quantity of water to be transferred to a user. as a function of time[2]. Most of the time, this type of manual control system may not be able to satisfy the requisite water demands, may result in inefficient utilization of available resources. According to a Survey, the overall water use efficiency of a manually operated system does not exceed about 40% in general. It is expected to increase about 10% in the overall efficiency for a system with some automation. The U.S. Bureau of Reclamation has published a technical manual ―Canal Systems Automation Manual that summarizes the work the USBR has done. They define canal automation to be the implementation of a control system that upgrades the conventional method of canal operation. The upgrades lead to more efficient use of water and improved response to demands[4]. Canal Automation in India is needed where land holding of farmers is very small and tail end reaches of canal suffering from inadequate water, severe crop violation. Canal gate Automation in India is speeded up in Karnataka. The Objective of Project is to discharge water accurately as per demand e, through automation of gate control mechanism. This type of Automation will not only save water but also decrease required manpower as well as increase Regulation of system.

II SYSTEM OVERVIEW

In the present system, the Canal Gate control administrator gets water demand from designated authority in terms of quantity of water is to be discharged in units of Cumecs and the time for which water is to be discharged. The discharge is the volume rate of water flow that is transported through a given cross-sectional area, measured in cubic meters per second, cumecs (m3/s). The LabVIEW platform through the graphical user interface (GUI) accepts user requests, undertakes necessary computations using standardized formulae, and calculates the amount of gate opening (height), and time for which gate is to be kept open and directs the arduino-based microcontroller system to operate the gate control mechanism. The system block diagram of Gate Control mechanism at canals is shown in Fig.1.

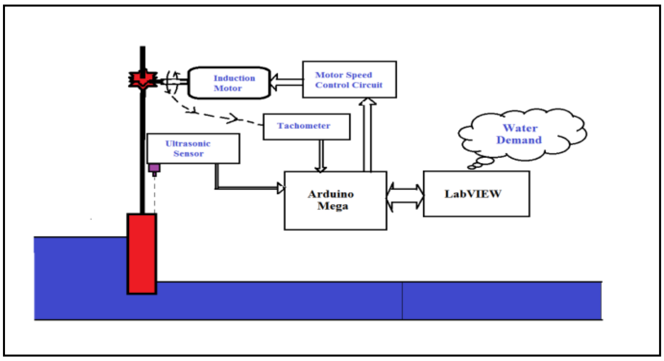

Fig.1 : Block Diagram :Gate Control Mechanism

The model of canal gate is displayed through Graphical User Interface of LabVIEW. The Motion of the Gate is simulated using Induction Motor through LabVIEW controlled GUI. Induction Motor shall operate the opening and closing of the canal gate. Induction motor will be switched on and off in forward and reverse direction using relays to open or close the canal gate as per the demand. The speed of the Induction Motor is controlled for varying torque experienced by Canal Gate. Tachometer used for monitoring speed of induction motor is implemented using Infra-Red (IR) technique, and is mounted near shaft of Induction Motor. The Ultrasonic sensor installed is HC SR04 for continuous monitoring of actual Canal Gate position. The Overall system is controlled using Arduino MEGA Microcontroller. The Arduino MEGA is programmed to receive commands for controlling Motor switching, Motor Direction and Motor Speed. The basic elements of a gate control mechanism includes sensors, an ac motor, with associated microcontroller based speed control circuitry, and LabVIEW based Graphical User Interface(GUI).

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

III SYSTEM OPERATION

In Phase angle control method, the Power and ultimately speed of motor is varied using control over the firing angle. The Firing angle is controlled using Thyristor like SCR or Triac. The Phase angle control method is cost effective, less complex and promising method. The disadvantage is speed variation is less as compared to other methods, which shall be acceptable. The block diagram of the gate control mechanism is as shown in Fig.2. Phase-angle control is often used to control the amount of voltage, current or power that a power supply feeds to its load[2]. It does this in much the same way that a pulse-width modulated (PWM) supply would pulse on and off to create an average value at its output.

The Phase Angle control consists of:
1) Zero Crossing Detectors:
2) Opto-Isolator
3) Phase Angle Control Circuit.
4) Triac
5) Arduino as Microcontroller.

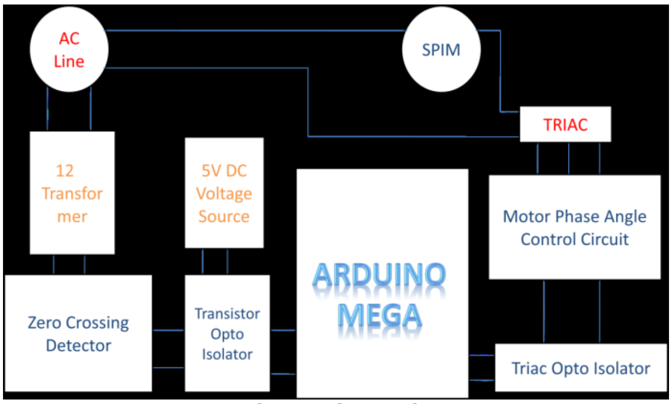

Fig.2 : Phase Angle control system

A zero crossing detector literally detects the transition of a signal waveform from positive and negative, ideally providing a narrow pulse that coincides exactly with the zero voltage condition. The pulse width of this circuit (at 50Hz) is typically around 600µs (0.6ms) which sounds fast enough. The problem is that at 50Hz each half cycle takes only 10ms (8.33ms at 60Hz), so the pulse width is over 5% of the total period

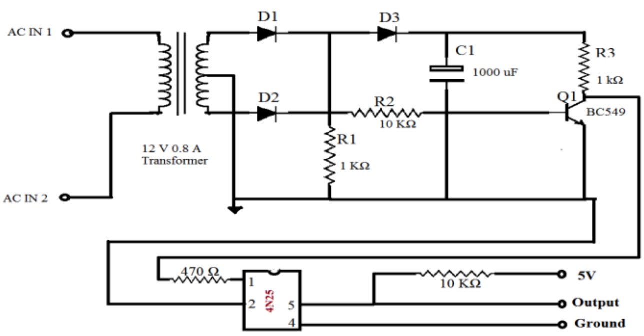

Fig.3 ; Zero-Crossing detector

R1 is there to ensure that the voltage falls to zero - stray capacitance is sufficient to stop the circuit from working without it.

The comparator function is handled by transistor Q1, The Output pulse has voltage of 12 v, So input to microcontroller is needed to be isolated from output pulse and ultimately from line voltage, The Opto-Isolator is needed to be used. The Photo transistor and Photo Darlington can be used for this operation, because these photo sensing devices will turn on for rising edge of pulse and will turn off for falling edge of pulse. So these devises are convenient and working for such operation.

The zero crossing detector shall give a positive pulse at each zero of both positive and negative cycles, At the time of pulses the output voltage of 4n25 will drop from 5V to 0V, and this will give a FALLING interrupt to Microcontroller. The line frequency is 50 Hz , so time period for each cycle is 20 ms and for each half cycle it is 10 ms, The phase angle control must be done in synchronization with applied Line voltage.
When signal of Zero crossing detector is sent to microcontroller as an interrupt, microcontroller will fire Triac at angle decided by user. This will be done in way that after receiving Interrupt, it will execute a program in which, circuit will be fired after delay in range of 0 ms to 10 ms in accordance with angle from 0 to 180. So user need to calculate delay according to angle. The input to Phase angle control circuit will be provided by microcontroller pin set to OUTPUT Mode. In accordance with delay the pin will LOW or 0V up to firing time after delay is completed the pin will be High or 5V, and this Interrupt routine will be executed each time to provide specified power to load, depending on the directives issued by LabVIEW platform for lifting or closing of the gate.

Sequential Event Management : As demand is conveyed to administrator, the parameters are calculated as preprocessing, after which administrator presses Start button so, at this event, the system should start, Motor should be switched on and direction must be set to forward, accordingly Gate should start lifting upwards. After it has reached the Target level, Induction motor should be Switched Off, accordingly it should stop lifting. After time is completed as per demand, the Induction motor must be again Switched On, and before that, it’s direction must be set to Reverse, accordingly Gate should move downwards, after it has reached bottom, Induction motor should be Switched Off, accordingly it should stop precisely, as coded in the LabVIEW block diagram of Fig.4.
Along with GUI and formulae LabVIEW program consists of Event Management, and LabVIEW and Microcontroller communication is done through Serial Communication[6]

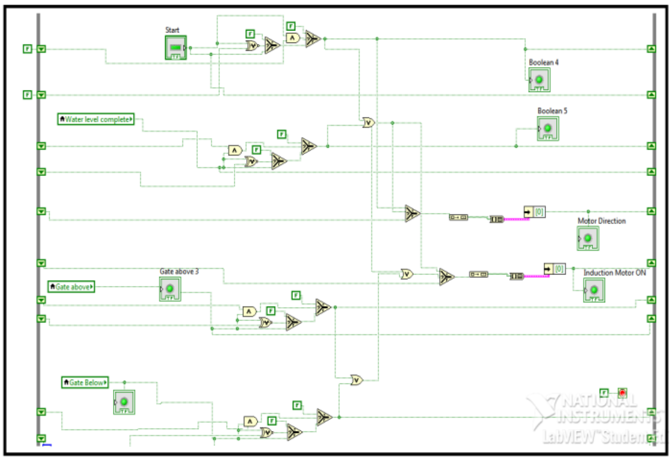

Fig.4 :Sequential Event Management for gate control

The LabVIEW platform calculates the necessary operational parameters for canal gate simulation. Before calculation of Gate opening, parameters like Load on Gate, Torque required by motor and other parameters are to be calculated, as mentioned below[1] :

1) Hydraulic Mean Depth (m)
2) Mean Velocity of Flow (V1).
3) Maximum Height of Upstream side.
4) Maximum Height of Downstream side.
5) Dimension of Canal Gate.
6) Present water level at upstream side
7) Present Water level at downstream side.
8) Final gate opening.
9) Load on gate.
10) Torque required by motor

Out of above parameters the first seven parameters are demand independent parameters. The Final Gate opening is calculated always once, after the program has received the water discharge demand. The ninth and tenth parameter, viz. Load on Gate and Torque required by motor, are calculated continuously throughout during canal gate opening and closing period. The ultrasonic sensors constantly monitors the distance(height) of the gate during gate open or gate close.

For convenience of simulation, the reference from the parameters at Mazalgaon Canal are taken into account[4]. It is an earth dam of 454 MM3 capacity, partly supplied by water from the upstream part of the Jayakwadi area, with a head discharge of 83 m3/s. The Head regulator gates are Rectangular shaped with approximate Dimension of 3.5 m (Width) *2.5 m(Height)* 0.3 m (Thickness).

Calculation of Operational Parameters for Canal Gate Automation are as stated below :

1. *Hydraulic Mean Depth (m)* : m=A/P

Where, A=Area of cross-section of canal, P=Wetted Perimeter

2. *Mean Velocity of Flow (V1)* : $V1=[w/f*m*i]^{0.5}$

w= Width of gate, m= Hydraulic Mean depth, i= slope of canal

f=Froude's constant of friction between water and side of canal for unit velocity= 1

3. *Final gate opening*[5]. :

$Q= Cd*B*Go*[2.0*g*(Y1-Y2)+(V1*V1)/(2.0*g)]^{0.5}$

where, Cd= Coefficient of discharge,

B= Width of gate

Go=Gate opening

Y1=Depth of water in rectangular section on upstream side of gate

Y2=Depth of water in rectangular sec tion on downstream side of gate

V1=Mean velocity in rectangular section on upstream side of gate

g= Gravitational acceleration,

4. *Load on gate*[1] :

$L=W+m1/2gh^2w$

where L= Load on the operator (lbs)

W= Weight of the gate

m= Coefficient of friction

g= Specific weight (taken to be 62.4 lb/ft3)

h= Height of water against the closed leaf measured from the bottom of the canal

w= Width of the gate

From [1], m = 0.35

The load L calculated from two upstream water depths h, the highest water mark and the lowest water mark.

i) Gate weight(W) and
ii) Weight of rising stem arrangement

Gate weight=Density of Iron*Dimension
=7.86g/cm3(Density)*2.5m(Horizontallength)*3.5m (Height)*0.3 m (Thickness)
=20.632 Tons=45493lbs

Weight of Rising Stem arrangement= 400 kg (aprox.) =882 lbs.

Total weight=46375 lbs.

5. *Torque required by motor* [1]: M= L*r*tan (q+ f)

where, M= Torque (ft lbs)

L= Load on operator

r= Radius of rising stem

q= Lead angle of rising stem

f= Friction angle between rising stem and brass nut

Using these standard formulae, following parameter values are calculated by the LabVIEW platform, as shown in Table-1.

TABLE -1 : PARAMETER VALUES

S.N.	Parameter for Simulation	Parameter Value
1	Gate Width	2.5 m
2	Gate Height	3.5 m
3	Gate Thickness	0.3 m
4	Gate Weight	45,975 lbs
5	Weight of Rising Stem	400 lbs
6	Radius of Rising Stem	5.683*10-5 m
7	Lead Angle of Rising Stem	0.0907 rad
8	Total Weight Considered for canal gate System	46375 lbs.
9	Maximum Height of Upstream side	10 m
10	Maximum Height of Downstream side	5 m
11	Hydraulic Mean Depth	1.323 m-1
12	Mean Velocity of Flow	0.588m/s

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

The graphical user interface(GUI) which acts as a front end for this model is shown in Fig.5. The system monitors continuously the opening or closing of the gate through ultrasonic sensors, and provides feedback to microcontroller module for fully opening(as per demand) or fully closing of the canal gate, ensuring smooth operation. At the completion of gate opening or gate closing process, the indicators on the front panels are set accordingly, showing 'Gate Opened', Gate Closed', etc

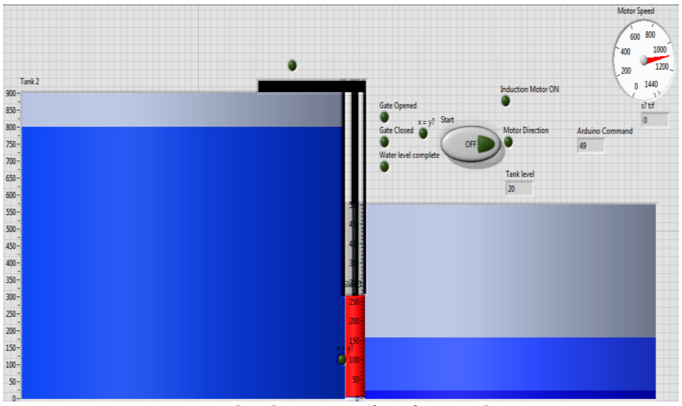

Fig.5 : Graphical User Interface for Canal Gate

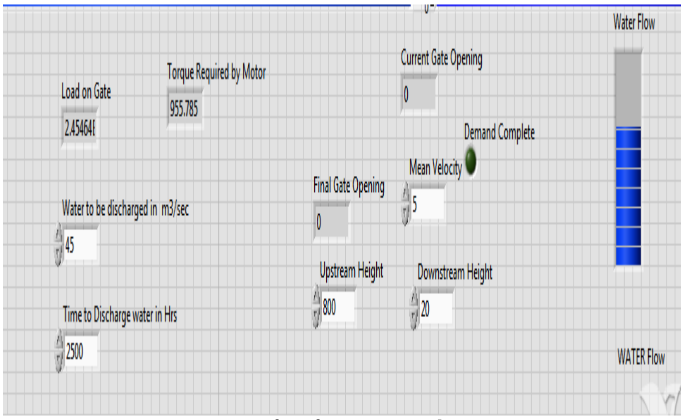

Fig.6 : User Interface for Operational parameters

The values shown in front panel of the graphical user interface(GUI) (Fig.6) indicates current status of the various operational parameters of the gate control mechanism.

IV RESULT AND CONCLUSION

The values of upstream water levels and the corresponding torque, speed values developed by the motor have been noted. Accordingly, the gate control mechanism for water discharge at canals work efficiently by lifting the gate to appropriate heights (gate open) and closing the same after the requisite amount of water quantity is delivered at the specific discharge rates, are given in Table-2

TABLE-2 : WATER DISCHARGE AND GATE OPENING

S. N.	Water to be Discharged In Cumecs (m^3/s)	Gate Opening in cms	No of Rotations of Induction Motor	Speed of Induction Motor (To open Gate in 5 min.)
1	2	11.5	323	1
2	5	28.9	809	162 RPM
3	10	57.8	1618	324 RPM
4	15	86.7	2428	286 RPM
5	21	121.3	3399	680 RPM
6	24	138.7	3884	777 RPM
7	29	167.6	4693	939 RPM
8	33	190.74	5341	1068 RPM
9	35	202.37	5663	1113 RPM
10	40	231.24	6473	1295 RPM
11	42	243.7	6798	1364 RPM

Following conclusions are obtained :

1) The gate control mechanism is successfully implemented and simulated for canal Gate opening and closing in terms of Induction motor controlling switching, direction and speed
2) The Motor phase angle control circuit and zero crossing detector together successfully perform function of phase angle control .The efficiency of zero crossing detector to 91%.
3) The speed control circuit successfully performed Speed control on experimental motor with no load. Speed control is obtained in range of 1168 RPM to 1445 RPM.

The user can easily control and monitor total system through software provided GUI . The GUI indicates actual status of complete hardware environment. Commands are successfully sent over GUI by user for control of Hardware environment The overall System works without any error and works within small delay of 200 ms from time when command is sent.

REFERENCES :

[1] Tyler Dean Richards, "Remote control and automation of the crockett", Utah State University DigitalCommons@USU.
[2] VARIABLE SPEED A-C MOTOR CONTROLLER FOR CANAL GATE HOISTS, U.S. Department of the Interior, Bureau of Reclamation Division of Research Hydraulics Branch, March 1983 Engineering and Research Center.
[3] CANALS SYSTEMS AUTOMATION MANUAL, U.S. Department of the Interior, Bureau of Reclamation Division of Research Hydraulics Branch, Volume 2.
[4] R.G. Kulkarni, Secretary, Irrigation Department, Maharashtra, The Majalgaon dynamic regulation pilot project, FAO Corporate Document Repository.
[5] Canal Automation Publication No.238, Central Board of Irrigation and Power, New Delhi, November 1993.
[6] National Instruments, ―Using the LabVIEW Shared Variable,‖ 2010.http://zone.ni.com/devzone/cda/tut/p/id/4679
[7] Boban Veseli˘c, Branislava Perunic˘ic´-Draz˘enovic´, Senior Member, IEEE, and C˘ domir Milosavljevic, "High-Performance Position Control of Induction Motor Using Discrete-Time Sliding-Mode Control", 0278-0046/$25.00 © 2008 IEEE.
[8] Shubhangi P. Bhat and Sunil R. Hirekhan,"Canal Automation Using LabVIEW", 2015 International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), pp.392-395