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Design for an Irrigation and Monitoring system of an Automated Dam

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***Abstract*—The industry has always focused to devise engineering methodologies for establishment and modification of relatively easier Controlling and Automation methods for any scrupulous process. This paper presents the design and implementation of a control system by means of microcomputers and data transmission networks. To verify the principle operation of the Controlling design to be presented a miniature Automated Dam model is experimentally tested using a PC-based system.**

***Index Terms*— Automation, Control System design, Dam, Monitoring system.**

I. Introduction

Controlling and automation of various processes, machines and devices is a fast growing business and application areas include fields as diverse as the industry, maintenance business, customer service, security, biology, medicine and social sciences. This paper presents the demonstration of a simple control system, and to do so the controlling of a Dam is considered and for this purpose a miniature dam was also built as a testing and simulation model. To enhance the features the test model is also fully automated and includes a PC interface for user inputs for important parameters, such as threshold or cut-off water level for gate openings, flow rate and Manual/Automatic mode selection.

With water playing a vital role in our daily lives, it is an important factor that cannot be eliminated and the potential lack of water in the future is a concern to one and all. Its distribution and usage is, therefore, of utmost consideration. Another issue rising with the passage of time is the requirement of energy and water, as it is increasing with the increase in population day by day. Hence to cater the above mentioned problems dams are built. Dams can fulfill these needs, as they are a source of hydro-electric power and water storage. Moreover, if dealt correctly Dams may present a considerable amount of benefit to national economies and to other related beleaguered beneficiaries. For instance, the Tarbela dam in Pakistan, contributes a heavy percentage of the country's electric supplies, about 20%, with its massive electricity production and thus relaxing the other electric suppliers, also with its efficient network it irrigates millions of hectares [1].

Prior to moving forward to the comprehensive analysis of the said miniature automated dam model a brief introduction of Dams is important so that it will be beneficial in the understanding of the changes offered in proposed model. A dam is a barrier constructed across flowing water course in order to control, direct, hold or raise the flow or the level of water [2]. The construction of a dam can be made from many non-erosive materials as diverse as rocks, concrete, steel and wood [3]. Since there are

numerous methods of withholding or preserving water, therefore, many different types and shapes of dam construction can be found. Dams are needed for many purposes, the indented purposes may include the preservation of excess water, effective measures for flood controlling, supply of water to various locations, providing water for the purpose of irrigation, improving industrial uses, proving space for the protection of fish and other wild life, production of hydro-electric power [4]. As there are many methods and purposes that exist to create a dam, various types of dam are also present. The factors which determine the type of dam to be built may include the following [3] [5]:

- ♣ The secondary products required, such as Hydro-electricity.
- ♣ The height of water to be accumulated.
- ♣ The construction materials to be used in the dam.
- ♣ The discharge amount and its rate.
- ♣ The geographical nature of the site which includes its width, shape and size.
- ♣ The labor and machinery being employed in the construction.

II. Objective

Apart from proposing and developing a control system the main objectives are to automate the dam to control the flow of water so that it can be effectively used in the irrigation system, to control the distribution of optimum amount of water to various areas, as considered necessary by them according to their requirements, also to control floods and prevention from the damages that can be caused by it and lastly to generate the electrical power for load driving. As often observed in usual Dams, in the rainy seasons, when the water level in the reservoir exceeds the danger level the water stored in the reservoir is flooded out to the fields which in effect would almost always damage the fields and farms in its way [6] [7], which in case of an agricultural country, for instance Pakistan, is of much more concern then otherwise. Along with controlling and automation, the model Dam built for testing purposes would cater this situation and would try to rectify this issue and would, in-fact, demonstrate how this hazardous scenario can be changed to a beneficial one.

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III. System Design

The importance and the need of dams are not new concepts, having discussed these factors we now move on to the design of the proposed model. The design of the model includes not one but two complete reservoirs, the upper and lower reservoirs, and both are embedded with eight different water levels which are electronically monitored by the sensors. These levels are not fixed in height or depth, the measure of which can be altered by the user, the reasons for which will be illustrated in the functional blocks section. At first the upper reservoir, as in conventional dams, stores the water offered to it and in case the water is found, by the sensors, suitably more than the required level it can then be transferred to the lower reservoir through the gates (interior spill ways, triggered by the control panel on the status of the level sensors) where it is feed to the distribution chamber. The distribution chamber is a very important part of the model, in addition to enriching the normal irrigation system, the distribution chamber distributes water among various cities or villages, the distribution chamber may include multiple pumps or pipelines to feed the different locations with the optimum amount of water, as described by them depending upon their requirements. The transferring of water from the upper reservoir to the lower reservoir is also used to produce the hydroelectricity; however this is considered a secondary purpose for the considered model. To demonstrate the proper working of the proposed model, the miniature model was assembled and tested under different scenarios to simulate the performance of the proposed dam under real conditions.

IV. Description Of Functional Blocks

To best illustrate the performance and working of the model, the different functional blocks are distinguished. These blocks operate in conjunction with one another to make the model work properly. The separated functional blocks of the proposed model in form of a basic block diagram is illustrated here in Figure I, which is reflecting the actual working progress of the automated dam irrigation and monitoring system, the function being performed by each block is mentioned below.

A. Upper Reservoir

At first the water starts to accumulate in the upper reservoir, and if found necessary the excess water should be evacuated to the lower reservoir by the orders of the control system. The explanation of the term excess water is here closely related to the levels being sensed by the sensors, there are two important levels out of the eight different levels, namely the upper threshold, danger or the flood level and the lower threshold, minimum or the dry level. If the water level in the reservoir is near the flood level the water would immediately be evacuated to the lower reservoir, where it is further distributed, but if the water level is near dry level the water will not be given to the lower reservoir even it is required by the distribution chamber. In other situations the appropriate amount of water will be given to the lower reservoir for distribution and irrigation purposes. The reason for not having fixed heights for the levels is that in different seasons the expected water to be stored is different and the levels are adjusted as per these requirements. For instance in the rainy or monsoon season huge amount of water is expected to be offered to the upper reservoir, so the water to be accumulated in this reservoir will be limited in order to reduce the flooding danger and giving margin to get the stored water evacuated before the new intake enters the system. Instead the water is stored in the lower reservoir but not distributed unless required, here the purpose of this block is same as in any conventional Dam, i.e. to preserve water and prevent from flooding.

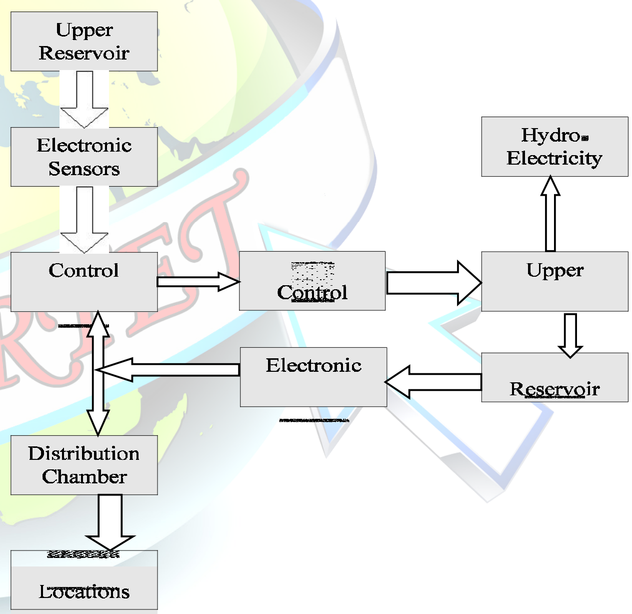

Fig. 1. Architecture of the proposed model

B. Electronic Sensors

The electronic sensors are used here for formulating the level status of the reservoirs. Each reservoir is provided with a set of eight sensors, one for each level. The level sensors present in the reservoirs will start to sense water level and feed this status to the control panel which also enables the displaying of the water levels on the screen with the help of a GUI (Graphical User Interface) in the PC based system. It will also set the desired parameters, such as the adjustable value of the water level to be considered as the Danger level set point. The danger or flood level (the level upon which

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the gates should open and water should be allowed to evacuate from the upper reservoir) can be selected from a range of eight different preset points. However it is appropriate to select a lower level for this in Monsoon season or when flood is expected, so that a greater margin for storage is available for the dam when the heavy amount of water suddenly enters the system.

C. Gate Control

When the water is found to be extraneous in the upper reservoir the control panel triggers the gate control unit to open the gates and allow the water to evacuate to the lower reservoir. The opening and closing of the gates for the interior spill ways are also to be controlled by the gate control unit, this is achieved in the test model by Linear Solenoids, and it will open and close on command of the gate control panel depending upon the level of water in the upper reservoir. When the water level exceeds the pre-set threshold of the danger level the gates are opened through energizing this linear solenoid, which consecutively pulls the gate up, emulating the interior spill ways and allowing the water to be withdrawn.

D. Upper Pump

This block may not be required in the actual dam but is required in the miniature model so that to provide the thrust for the water leaving the upper reservoir to generate the hydro-electricity as the height of the test model is not as such to provide the required speed for the turbine (dynamo) to rotate appropriately for power generation. Sensing the presence of water the gate control unit instructs the pressure pump to be activated, resulting in a pressure in the flow of water leaving the upper reservoir and producing hydro-electricity.

E. Hydroelectricity - Dynamo

As water is transferred down to the lower reservoir, producing spillway effect, the pressure of this will make the turbine rotate and the dynamo motor will be activated [8], resulting in the generation of small amount of voltage since the pressure required for the generation of a considerable amount of Hydro-electric power is unavailable in the said testing miniature model of the Dam. As told earlier the hydroelectric power generation is considered a secondary function in the proposed model.

F. Lower Reservoir

The water that slides down will accumulate in the lower reservoir, here instead of flooding the water out from the upper reservoir directly to the exterior spillway or fields, the water is first stored in this reservoir and then this stored water can now be navigated to remote areas where water is required, which may include cities, villages and even a sea. This navigation is achieved by the distribution chamber. The lower reservoir is also embedded with the set of eight water level sensors for monitoring, which regularly updates the control panel of the status of the reservoir.

G. Distribution Chamber

The distribution chamber is another important aspect of this proposed model. Located in the lower reservoir, it includes in it multiple pumps or irrigation route outlet pipes. When the water is stored in the lower reservoir, the distribution chamber allows the water to be transferred to the remote locations, depending upon the need of these remote locations. If the remote locations are in need of water when there is no or less water, like near the dry level of lower reservoir, then the distribution chamber provides the main control panel a signal and depending upon the upper reservoir's status the water is provided to the lower reservoir, if applicable. In the rainy season or in case of flood, the main advantage of this distribution chamber is that it will provide in conjunction to the conventional exterior spillway these other additional pumps which will distribute the water in various locations, including a sea (if available) to draw off the extraneous water. Hence it limits the chances of flooding by distributing the load and allowing more evacuation rate. Submersible pumps inside the lower reservoir perform the duty of the distribution chamber in the test model.

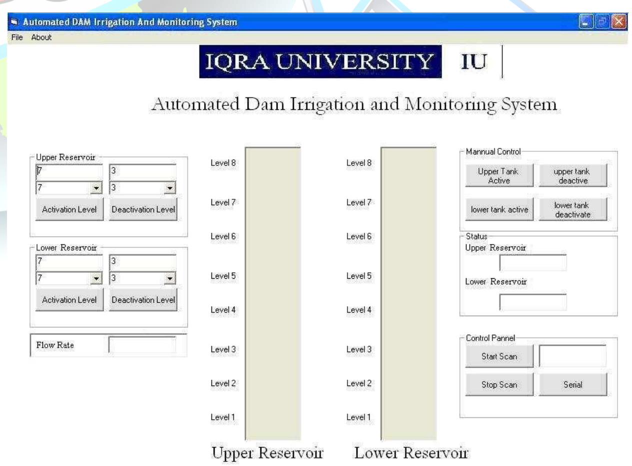

Fig. 1. The GUI of the system

H. Control Panel

The control panel is the most important part of this automated dam irrigation and monitoring model. The

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managerial duties of it include the controlling of all the gates, valves, the distribution chamber and the pumps. The control panel is also supported with a GUI, which facilitates a quick status check of the entire system and also defining important decision making parameters like determining the flood or activation water levels and dry or the deactivation water levels for pumps in both the reservoirs. Initially the level sensors take the water level status of the upper and lower reservoirs as its input, and feed this status to the microcontroller through two of its ports. The microcontroller then feeds this monitored status of the reservoirs to the Computer based controlling unit through the serial port, as the level of water rises in the actual system it will also increase on the screen for both the reservoirs in the virtual system. This will provide the information about water level, consumption rate, and rainfall and dam capacity. Figure II illustrates the Graphical User Interface (GUI). The GUI analyzes this provided status and also considers the danger level margin as described by the user through the computer interface. The computer interface enables the operator to control the flow and the decision making at any given time, for instance it includes manual and automatic control. In the automatic control the user gives the activation and deactivation levels for both the reservoirs and the computer constantly compares the status of the reservoirs with these user defined inputs. Upon the analysis of the PC interface the triggering signal is given to the microcontroller which controls the gates and pressure pumps operation in the miniature testing model, giving the effect of interior or exterior spill ways. In the manual mode the user has the option to activate or deactivate the gates and the spillways at time one considers necessary. The control panel also allows determining the flow rate of the system.

V. The Rating Table

The miniature testing model of the automated dam irrigation and monitoring system uses the components with the ratings as shown in Table 1.

TABLE I
Ratings of Components Used

Device	Specification
Electronic Sensors	12VDC
Linear Solenoid	Input=220 VAC
Dynamo	Voltage Rating 5V Current = 0.1 mA
Pressure Pump	256 VAC ; 40 m Amp Cycle 60 Hz
Solenoid Valve	220 VAC ; 2.5 Amp Cycles = 50/60 Hz
Relay	220 – 240 VAC 5Amp Cycle: 50 Hz Operating Voltage: 24VDC

VI. Experimental Results

The miniature testing model of the Dam was created to simulate the controlling and operation of the proposed automated Dam. The test model was experimented with almost every possible scenario that can be imagined and some very interesting results were found out. Apart from implementing the automated control system the model of the said Dam showed experimentally that with the usual benefit of a dam being prolific in Hydro- electric power generation, this testing model also provided with the added advantage of excessive water storage, excessive water here having the meaning of the water being discarded by any other usual dam is also effectively utilized in this proposed model. The water stored in the lower reservoir – Reservoir 2- is sometimes four to five times more than the water stored in the upper reservoir, which shows that the lower reservoir holds more water than the water available for a particular session- as in any other usual dam the water in the solitary upper reservoir is all that will be used. In the rainy season the upper reservoir serves as the active reservoir and lower reservoir holds the advantage of preserving and distributing the extra water to be evacuated in a conventional dam. Whereas in the dry season with the upper reservoir holding very little amount of water the lower reservoir can still provide the water stored in the previous season, however seepage [9] in reservoirs should also be considered here.

VII. Conclusion

In conclusion an automated control system for the irrigation and monitoring of a dam was developed. The control system presented was supported by a test model and the dam model proposed included some added features which thrive to make the most out of a normal dam. Apart from the benefits discussed in the above section the other benefits and conclusion drawn from this paper can be that, as far as the control system is concerned, the same control system is suitable not only for simple and similar applications but also for application in many different areas like it can be used for monitoring a car parking lot or any other application where decision making is required on the basis of some sensor inputs. This paper shows the use of the said system with the assist of the PC based interface, however for future purposes, if a standalone system with more enhanced features with smaller size and is also portable the design may include the microcontroller with program downloading facility, also the use of a PLC is a superior option for such a case or the system may include Supervisory Control And Data Acquisition (SCADA) system.

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