REMOTE CONTROL SYSTEM IN DOUKKALA

by

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The Office of Doukkala chose remote control system to improve the regulation and the operation of the existing Low Main Canal (CPBS) and prepare for management of the future High Main Canal (CPHS). The project is based on high technologies and recent developments in electronic, automatic, telemetry and computers.

The Remote Monitoring System of CPBS has already gone through the phases of design and installation. It is now under a phase of test and adaptation.

The paper is divided in the following sections:

1. Hydraulic and agricultural equipment of the low sub-scheme
2. Usual operational problems in CPBS
3. The remote control system
4. Conclusion

1. HYDRAULIC AND AGRICULTURAL EQUIPMENT OF THE LOW SUB-SCHEME

The low scheme covers an irrigated area of 62 292 ha (1994). Irrigation is achieved through the following equipment:

- Imfout reservoir:
  area 907 ha -
  maximum level +190 m
  initial capacity 80 Mm3
  current capacity 20 Mm3

- Tunnel:
  length 17 km
  diameter 5.3 m
  discharge 36 m3/s

- Main Canal CPBS:
  length 111 km
  upstream discharge 42 m3/s
  tail discharge 6 m3/s
  regulation with Amil gates (upstream control) from km 17 to km 34
  intermediate zone between km 34 and km 57
  regulation pond at km 57 (+ 174.20)
  regulation with Avis gates (downstream control) from km 57 to 128.

- 5 Irrigated sectors between 9844 and 15 922 ha each.

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2. USUAL OPERATIONAL PROBLEMS IN CPBS

The main canal CPBS was designed initially to supply surface irrigation on a rotational basis, i.e., with a continuous constant discharge. This concerns sectors Faregh, Sidi Smail and Sidi Bennour equipped between 1953 and 1973. This first phase corresponds to CPBS between km 21 and km 77, having a composite regulation mode:

Regulation with Amil gates (upstream control) from km 17 to km 34.
Intermediate zone (non regulated) between km 34 and km 57.
Regulation with Avis gates (downstream control) from km 57 to 77.

The later development (1975 to 1982) of sprinkler irrigation on free access service, in the downstream part below km 86, has generate problems in the regulation, due to stochastic variations of discharge. Perturbation impacts are deficit or spills. They occurred essentially in the non regulated intermediate zone.

Perturbations were classified as follows:

- Stochastic perturbations:
  - non consumption of discharges requested
  - over consumption with respect to the demand
  - unscheduled issues from ONE (electricity company)
  - unscheduled stop of pumping station
  - break of aerial concrete canals
  - break of large pipes for sprinkler irrigation
  - variation of water level in Imfout reservoir

- Perturbations requiring permanent monitoring of the gates:
  - blocking of automatic gate (natural cause or vandalism)

- Perturbations requiring regular works of cleaning and service:
  - silt deposit and aquatic vegetation

Another difficulty in operating the canal is linked to the pumping station Bir El Abid, fed at the downstream end of the intermediate zone. This pumping station requires that water should reach a minimum level, varying between 173 and 173.6, depending on the numbers of pumps simultaneously functioning. Unfortunately, this high precision requirement applies in the highest sensitive section of the canal CPBS.

3. THE REMOTE CONTROL SYSTEM

3.1 Introduction

In 1985, ORMVAD asked a consultant company (ADI-GERSAR) to undertake a study on the regulation of the CPBS of Doukkala, with the goal of solving the operational problems met.

This study was realized in three phases:
Phase 1. Analysis of existing regulation modes and building of a simulation model.
Phase 2. Comparison of different solutions.
Phase 3. Detailed study of the chosen solution.

Solutions studied were:

1. Increase of the compensating pond capacity.
2. Extension of downstream regulation mode at the upstream part.
3. Remote control.
4. Remote command.
5. Remote monitoring.

Solution 5 was finally retained and the monitoring based on four measurement points. In addition, the extension of the relation pond capacity from 33,000 m3 to 65,000 m3 was planned.

3.2 Description of the Remote Monitoring System for CPBS

The Remote Monitoring System (RMS) is composed of a central unit (PC) located at Sidi Bennour and fours secondary units (PS) located at Imfout (PSO), at km 57 (PS57), at pumping station Bir el Abid (PSB) and at km 84 (PS84). The central unit receives in real time, through a radio network, information from PS units.

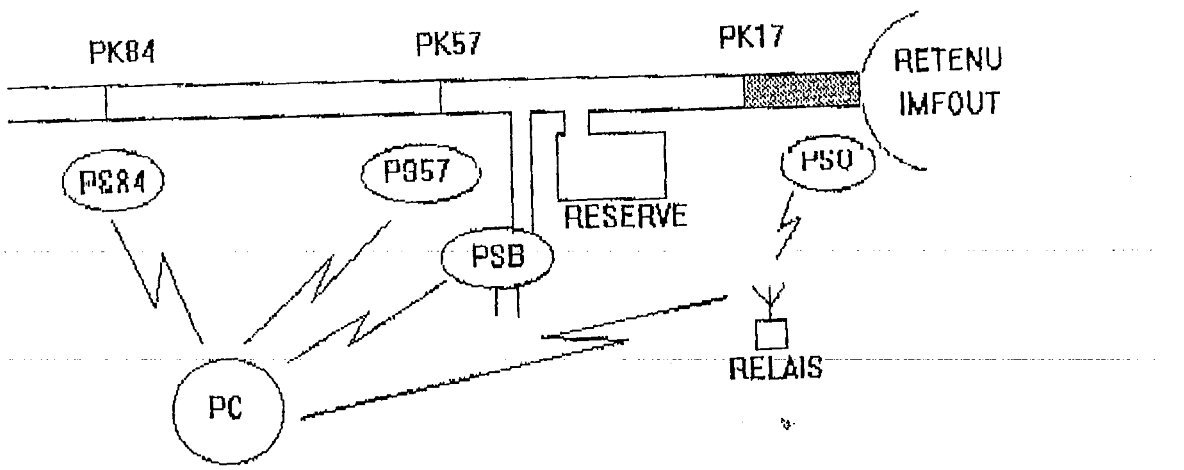


Figure n° 1

The choice of PS 57 and PSB was imposed by the necessity of controlling water depth at pumping station. PS84 allows to anticipate on water needs for the sectors Zemamra and Gharbia under sprinkler irrigation, before variations of the discharge impacts km 57. Accordingly, proper intervention at Imfout dam, can be made, taking into consideration that time lags between PK0 and PK57 and between PK57 and PK84 are similar.

3.3 System architecture

Four levels are distinguished:

- Level A: it corresponds to the information acquisition (sensors and probes).
- Level B: it processes local information and transmits them to the central unit.
- Level C: it manages all the links through the network and with the manager: control of the communication with the units, interface, reports and outputs.
- Level D: it aims to process data collected and treat it in the regulation unit. This was the DSS system.

3.4 Equipment for the Remote Monitoring System

A large attention is paid by the manager to maintain properly the system. Talking of new high-tech equipment, maintenance is more ensuring the awareness about new equipment that can improve the quality of the system.

i. Measurement sensors:

Accurate water level and discharge measurements are crucial for the reliability of the monitoring system. Sensors are fragile and require a proper service and maintenance.

a. *Level measurements:*

Pressure sensors equip PS0, PS57 et PS 84. Hydrostatic pressure is transmitted to a condenser which converts the information into continuous electricity.

Ultrasonic sensors equip PS57 and PS 84. An acoustic wave is emit by the sensor and reflected by the water surface. The same sensor measures the time-lag between emission and reception of the wave. This time value is then converted in distance and height. The sensor is not in touch with the stream, this is one of the advantage of this technique.

b. *Gate opening: Height and angle:*

This type of sensor is used to assess gate opening angle at PS57 and PS84 (type GVI) and to measure height opening of the motorized gates at PSO (type G2G).

c. *Discharge measurement:*

At PS0, the head of the system, a double measurement is made. One is a direct measurement with an ultrasonic discharge meter, the other is the result of a computation based on water levels upstream and downstream the gates and opening values.

At PS 57 and PS 84, discharge is computed using water levels and opening angle of the gates.

ii. Telemetry and other equipment:

A technical description of telemetry equipment and interfaces is given in the French version of the paper; details can also be obtained from authors.

iii. Regulation software:

This software has been developed specially for the regulation of CPBS. Its goal is to produce an optimal trajectory for issues taking into consideration prediction of the demand and current state of the canals.

Written in language C, this software is an expert system using fuzzy logic to build discharge targets.

a. *The state variables du CPBS:*

State variable of CPBS			
PS0	**PS57**	**PSB**	**PS84**
Upstream level Downstream level Opening gate 1 (height) Opening gate 2 (height) Discharge computed QcO Discharge measured QuO	Upstream level Downstream level Opening gate 1 (angle) Opening gate 2 (angle) Discharge computed Q57 Level in the pond	Discharge Qb	Upstream level Downstream level Opening gate (angle) Discharge computed Q84

b. Intermediate variables:

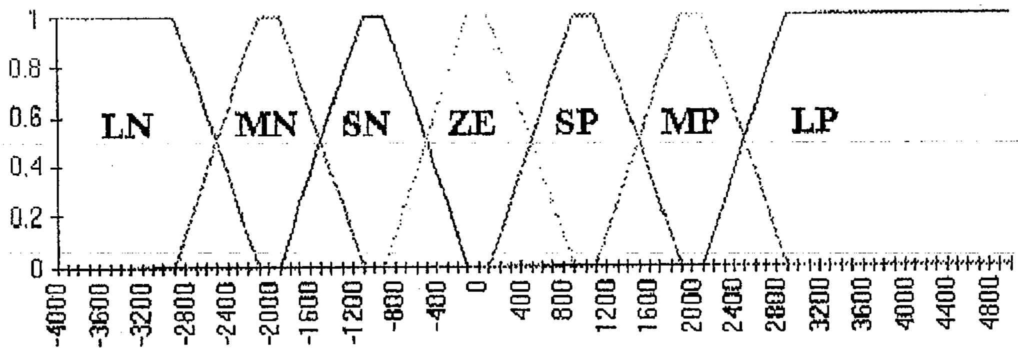
b1. Planned discharge Qp: Computed from predicted water needs and/or demand.

b2. Optimal volume in the pond: Optimal volume in the pond is linked to instantaneous consumed discharge; two extremes situations allow to illustrate how:
- if discharge is nil, then there is a great interest to have the pond full, since the only possible event is a demand for discharge.
- if discharge is maximum, then the pond should be at its minimum level, since the only possible event is a decrease of the demand.

c. Regulation variables:

V1 = Qp-Qu0
V2 = Vopt -Vrr (Vrr = actual volume in the pond)
V3 = Discharge gradient (in time) at PS84
V4 = Gradient (in time) of the volume in the pond
V5 = Vn-Vf (Volume required - volume delivered in the canal)

d. Memberships functions to a set of domain:



Fuzzy logic is specifically used here to define the membership of a variable to a set of overlapping domains. Fuzzy domains are:

LN	highly negative	MN	medium negative	SN	slightly negative
SP	slightly positive	LP	highly positive	MP	medium positive
ZE	zero				

Example: With V1= 2.6 m3/s and a 500 gain value, we have Vr1=1300
Vr1 belongs to SP at 78 %
and to MP at 22 %

e. A set of rules:

It is a set of rules identifying the domain of application of the command variable, from the domain membership. The command variable here is the correction to be applied to the head discharge (main issue).

In the software, the rules are written as follows:

IF V2-MN and V5-MP THEN head discharge correction = ZE *f. Definition of the discharge target:*

For each regulation variable, discharge target is expressed in a linguistic form.

The aggregation of the recommendations for each variable is proceed using a weighting fuzzy method. It leads then to the total discharge target converted into numeric form.

One example of fuzzy logic control has been developed on a spreadsheet (Excel), for the purpose of training and demonstration (details can be obtained from the authors).

4. CONCLUSION

The RMS had been recently installed, and we have now 6 months of experience. The RMS is still under validation and test phases.

Although it is too early to draw founding on how the system operates, we would like to conclude by listing some of the important aspects in the development of the project.

High-tech equipments are so broad in term of properties, so diverse in the type of solution for which they are best suited, that the "choice" is crucial and difficult to made. Bounding the problem to be solved and choosing accordingly the adapted equipment are important in the design. Avoiding complexity in operation and maintenance was one of our goal in the design of the project.

Visit to similar projects and discussions about other experiences is also important to master the project.

A progressive approach was felt more adapted, here, than an full automation, covering the entire system. The implementation of the Remote Monitoring System is made by steps. This allows for changes and adaptation.