Intelligent Control System for Monitoring Drilling Process

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Abstract : – World wide drilling is developing for oil, gas or water resources. Electric motors power 75% of the total drilling rigs installation, augmenting to 95% for the case of Romania. Monitoring diesel generators micro-power station and motors of the rig is the second important thing to do and complete the main task of drilling process monitoring. This paper describe a monitoring and control system intended for inland and offshore drilling rig applications.

Key -Words: - Drilling process, monitoring, intelligent control, virtual instrumentation

1 Introduction

Conventional resources drilling process means continuous investigations to find out new sources, investigations finalized mostly with deep drilling operations (1000 ÷ 6000 m) to extract the so-needed fuel.
Regardless of drilling type – with hydraulic diesel installations for remote areas or electrical installations where power-line supplies are available - remote control and parameter monitoring of drilling installation must be done (usually from a platform located 10 m above ground) in order to achieve good results in the process.
Generally, drilling control and monitoring process is performed from the so called: “chief driller desk” which is located at the main running level of the oil well (gauge circa 1000 x 600 x 1600 mm), where all the elements of human-machine interface (HMI) monitoring system are located [1], [2], [4], [7], [10]. The main parameters of the drilling process monitored by the system are [3], [5], [6]:

- rotational speed of mud pump drives;
- rotational speed of hoist drive (granic);
- rotational speed of rotary table;
- drive torque of rotary table;
- mud column pressures and flows
- drilling depth;
- currents, voltages, frequency of supply source;
- auxiliary service pressures and flows etc.

To control drilling activities, these drives and motors are controlled by a command and control station (named SCR) which is manned by the chief driller (named PS), as shown in figure 1. These SCR are provided by the electrical drilling equipments provider.

2 SCR function in drilling platform

SCR operates high power motors of drilling process – figure 1: draw works (M1), rotary table (M2) and mud pumps (M3,M4)

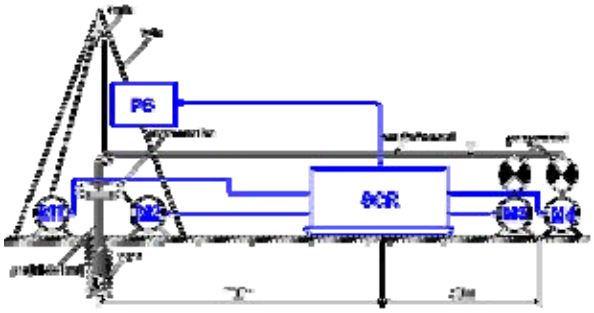

Fig.1. Position of chief driller desk (PS) and of motors involved in drilling process

2.1. Monitoring system architecture

Control and monitoring elements, are stand alone measuring apparatus and devices using buttons, potentiometers and mechanical switches (n, A, V, p, D) which are sending and receiving to and from motors and drives different voltage signals [8], [17], [18], [19].

The main drawbacks of this procedure are:

- remote transmission of electrical signals is altered by the strong electromagnetic fields in power supply-burden connection area;
- the human operator doesn't have simultaneous control of all drilling parameters;
- the over sized gauge of chief driller desk;
- low viability of switching devices for long term use;
- missing parameter concentration and non-existent variable integration makes operator decisions to be slow;
- missing ergonomic aspect of chief driller desk: due to increased size and complexity, human operator will work in stand-up position, becoming easily tired during activities.

The monitoring system presented in this paper improves these conditions using the flexibility of a PLC based monitoring with computer level human interaction. In figure 2 is described the principle of a drilling installation having as main elements the drilling shaft, the hoist, rotary table, mud pumps, and drilling head. The electrical drive of the installation consist in 3 to 9 DC/AC motors.

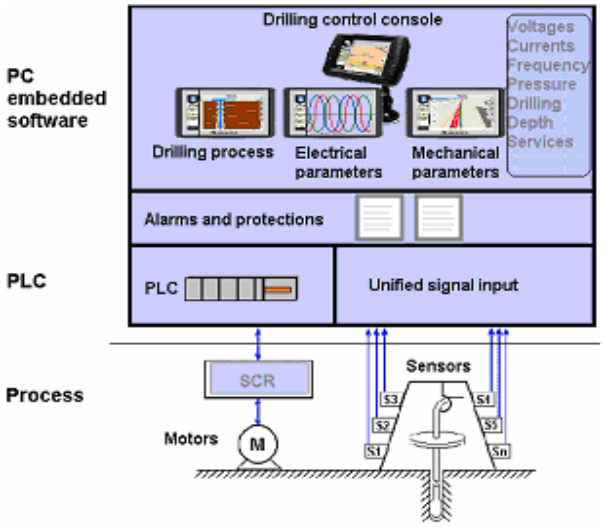

Fig.2. Computer based monitoring of the drilling rig.

The aim of activity is to integrate the standard CCS control desk into a computer based work post which: allows control and drill parameter monitoring, save the data plus the chief driller commands into a database to build a black-box of the station and also improve the protection level of such complex equipments. All these can be obtained using a command controller for drilling software based on:

- PC + PLC + software instruments – console equipment to replace the existing devices on the drilling platforms;
- optical fiber data transmission for variable rotational speed motors and for the measurement sensors involved in drilling process;
- PLC + interface software with connected equipments;
- data processing software and interactive graphic tools allowing friendly use functions to human operator for the most important drilling parameters.

The interface must be reconfigured with the latest technologies keeping door open for future developments and upgrades.

This system is an absolute new idea for Romanian drilling industry; other attempts to integrate real time parameter monitoring systems are not announced until now.

2.2. Monitored parameters

Beside monitoring up-to-date drilling parameters this project is designed as an open system ready for future

developments to allow complete control and automation over drilling installation [11], [12], [14].
The equipments which are monitored at this stage are the following (figure 3):
- diesel generators type Caterpillar having 1500kVA at 600V (symbol GEN);
- connection switches to main power supply distribution used by generators (symbol QG);
- rotary drive converter (symbol CT);
- connection switches to main power supply distribution used by converter (symbol QC);
- excitation converter (symbol Ex);
- connection switches to main power supply distribution used by excitation (symbol KEx);
- connection switches to auxiliary power supply distribution used by transformers (symbol QTA);
- parallel connection switch for auxiliary transformers output (symbol G1.Q0);
- battery charger;
- electrical drive motors status (visual symbols).

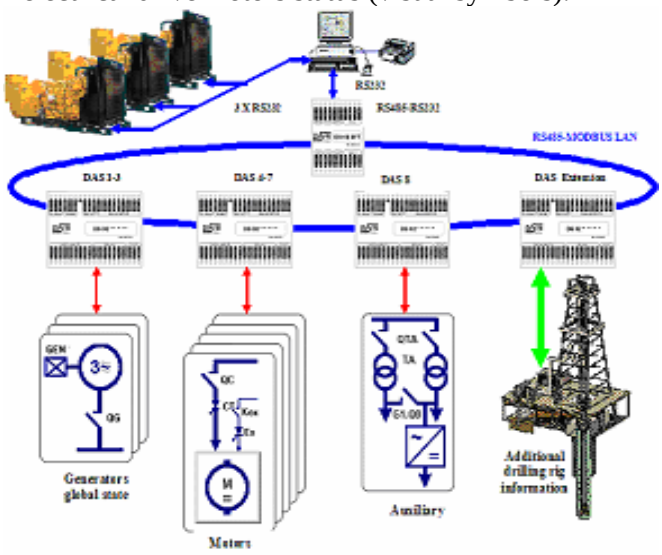

Fig.3. General drilling process monitoring.

The implementation of computer controlled monitoring system can be discussed in two directions: regarding both hardware and software aspects.

2.2.1. Monitoring hardware equipment

Drilling Diesel generators are delivered with a serial communication system. To connect them into the monitoring system an auxiliary control device using PLC has been completed, as shown in figure 4.
Power converters functioning status is also monitored with a PLC, (see figure 5), regarding both electrical and excitation parameters.
Additional equipments monitoring is shown in figure 6, for secondary supply network, including battery charging and transforming system.

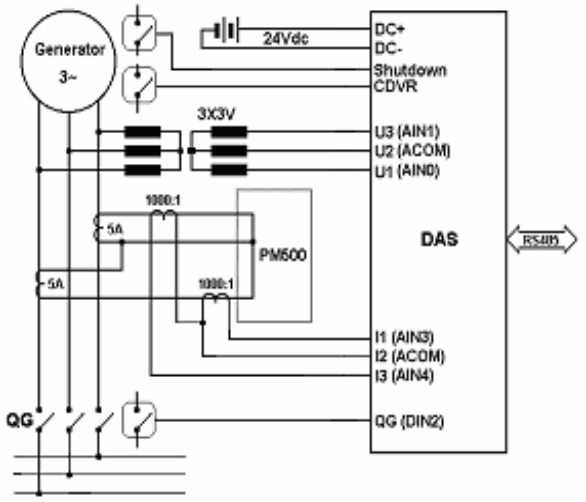

Fig.4. Generator currents and voltages acquisition block.

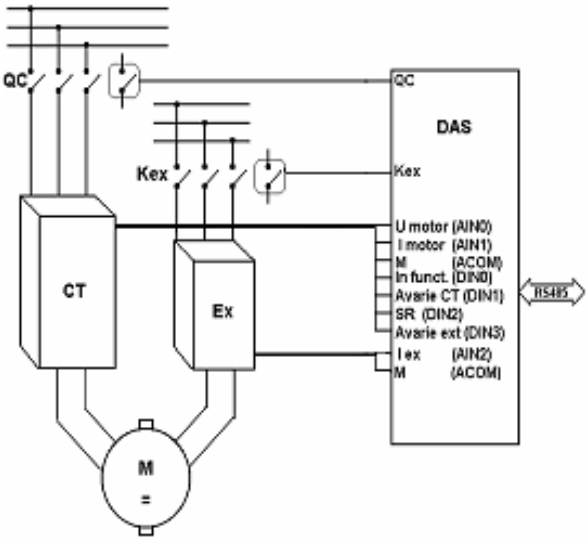

Fig.5.Connection schema to monitor stator and rotor excitation windings of the motor .

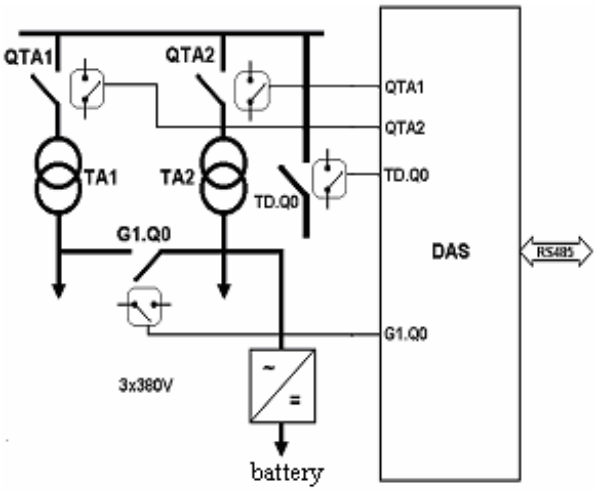

Fig.6. Monitoring solution of auxiliary equipments.

2.2.2. Monitoring software

The software interface to monitor electrical drive equipments consist in two different parts [9], [13],[15], [16]:

• Software designed for execution system processors which is responsible for data acquisition process;

• Software installed on the coordinator PC which allows data communication, real time data storage, control of the application and the management of alarm system.

The main window of application control system is shown in figure 7, with user having access to main drilling systems and receiving global information about how these systems work.

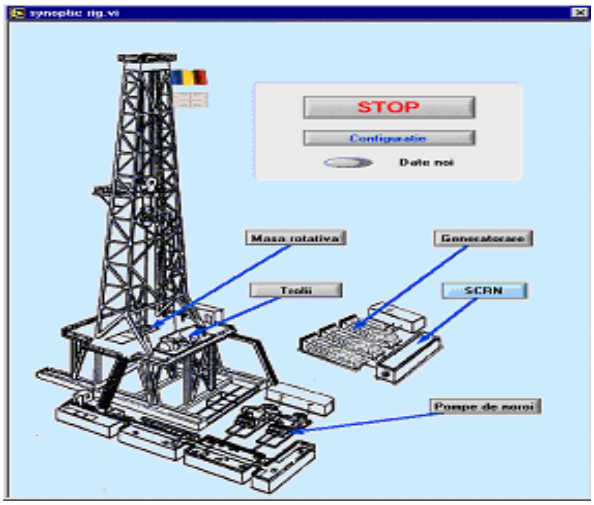

Fig.7. Main window of the monitoring application.

Selecting “SCRN” button, electrical equipments synoptic window can be displayed, as shown in figure 8.

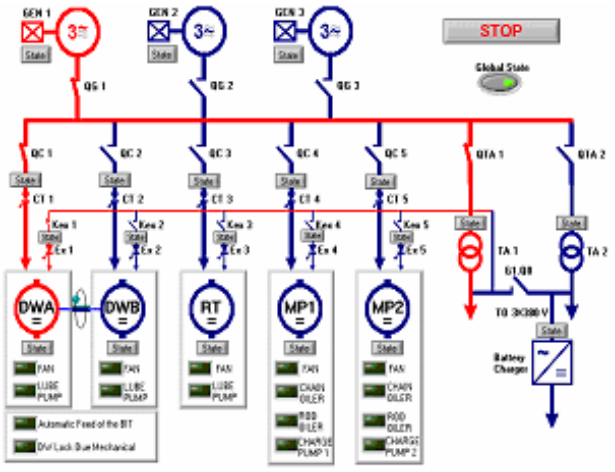

Fig.8. Drive installation synoptic with monitored parameters.

The mono type schematic with all equipments is displayed, detail about status of each equipment can be obtained, activating “Global State” control button

which add on display different status buttons for all elements. Activating one of these 

buttons, new control windows will be displayed, accordingly:

- Figure 9. Diesel generators status window;
- Figure 10. Rotor and excitation drive converters status window;
- Figure 11. Hoist motor status window;
- Figure 12. Rotary table motor status window;
- Figure 13. Mud pumps status window.

This design of these buttons allow additional display opening to inspect equipments status at different levels without loading the main window of program each time.

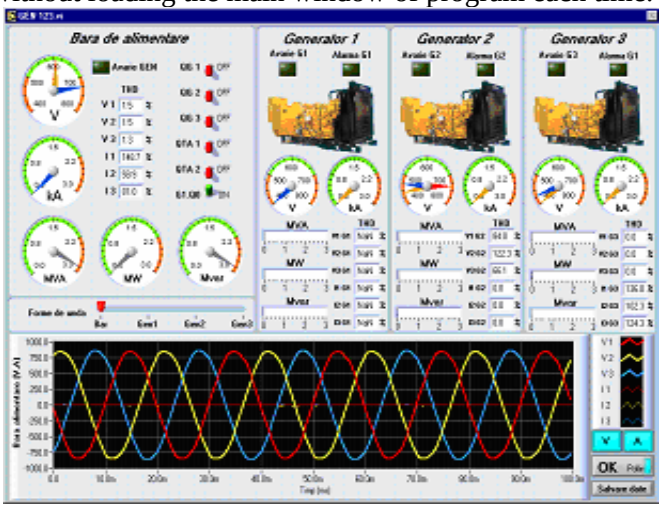

Fig.9. Diesel generators status window.

Diesel generator controls show electrical parameters: such as generator voltage and current, including wave forms, RMS values and THD, and also show binary information about warnings and alarms concerning overcharging situations or power supply connection problems. Parameters describing the status of these modules are binary showed (on/off), with both integrated draw (left side of figure) and functional intuitive symbols for each system.

Fig.10. Rotor and excitation drive converters status window.

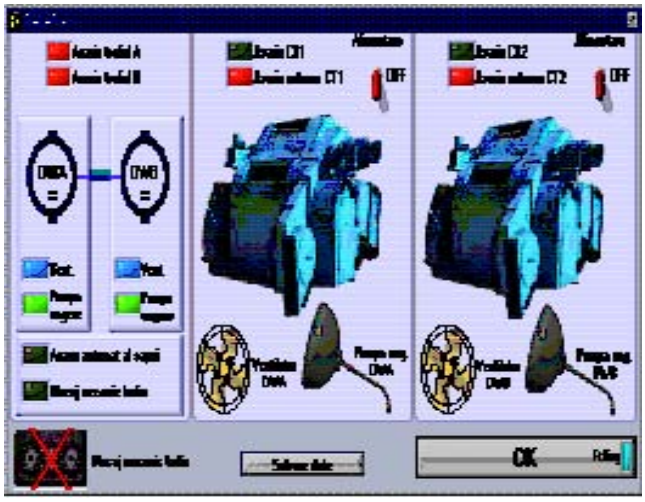

Fig.11. Hoist motor status window.

Many of drawing elements from control windows are animated to increase efficiency and easy to use characteristics.

Fig.12. Rotary table motor status window.

The left side button allow global inspection of parameters at power supply level and each equipment status is shown in the right side of display.

Fig.13. Mud pumps status window.

3. Conclusions

An intelligent monitoring and control system for both inland and offshore drilling platforms is no easy task to compute. Distinct local drilling conditions must be taken into account.

The intelligent monitoring system is based on SCADA architecture with PLC hardware equipment connected to a mainframe server via MODBUS communication system. Electrical parameters monitored are giving information about drilling process general status, about evolution of electrical parameters of drive motors involved in the process and about evolution of other parameters describing drill operation, such as: pressure, direction or temperature in different points of the system. All these information are saved in a real time data management system allowing control and warnings at different levels, depending of their severity.

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