Computer Added Monitoring of Drilling Rig Systems

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Abstract: – This paper describes a computer added system for monitoring and control for inland and offshore drilling rig appliances. LabVIEW graphic oriented software provides a flexible and reliable support for SCADA. World wide drilling is developing for oil, gas or water resources demanding computer added monitoring and control for exploitation and supervising personnel. This applied engineering software offers a complete monitoring for diesel generators of the local power station and electrical drives of the drilling rig.

Key -Words: - computer added monitoring, drilling rig, monitoring software, virtual instrumentation

1 Introduction

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], [3], [4], [5].

The drilling process is a decisional one, highly ordered and hierarchic with a strict sequence of operations to follow.

The development of newer software platforms, such as LabVIEW proves to be a useful tool for developing application and engineering software for high reliability

and risky processes, as drilling for new resources.
Regardless of drilling type – with electrical installations where power-line supplies are available or hydraulic diesel installations for remote areas - remote control and parameter monitoring of drilling installation must be performed (usually from a platform located 10 m above ground) in order to achieve good results in the process.
The main parameters of the drilling process monitored by the system are [6], [7], [8]:

- rotational speed and sense of draw-works;
- rotational speed of mud pump drives;
- rotational speed and sense 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.

More than 75% of the total drilling rigs are powered electrically. To command drilling activities, these drives and motors are controlled by a command and control station CCS which is manned by the chief driller (named PS), as shown in figure 1. Usually the command and control system is provided by the electrical drilling equipment manufacturer.

2 Control function for drilling platforms

One basic schematic of the power actuators for the rig is presented in figure 1. Control operates high power motors of drilling process: draw works (M1), rotary table (M2) and mud pumps (M3,M4)

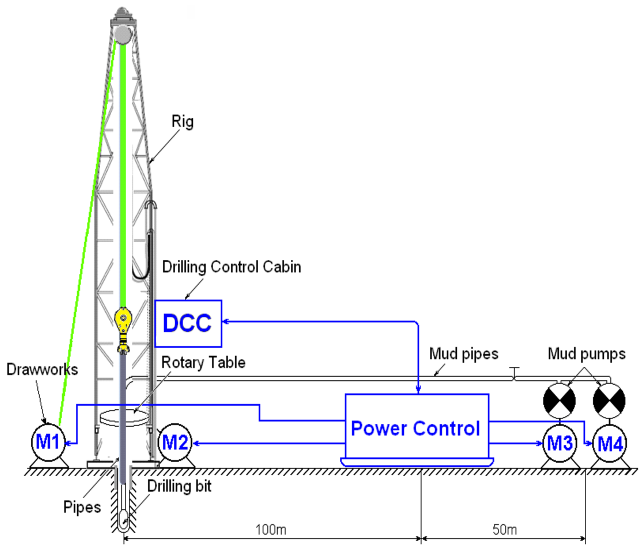

Fig.1. Position of chief driller desk (PS) and of motors involved in drilling process

2.1. The architecture of monitoring system

The actual implementation of the software follows the supervision needs for all essential equipment of the drilling rig, starting with the very basic drilling holes drivers and covering all the range to auxiliary appliances. Control and monitoring elements are stand alone data acquisition system for specific sensors monitoring bought mechanical and thermal values of the process and electrical parameters referring to the state of the driving motors and local power generators. [9], [11], [12].
Traditional data grabbers systems have several drawbacks in the case of the complexity of a drilling rig:

- remote transmission of electrical signals is influenced by the strong electromagnetic fields;
- in classical gauge oriented design the human operator doesn't have friendly control of all drilling parameters;
- the over sized and open air chief driller desk;
- low reliability of electromechanical controls for long term use in hostile work environment;
- slow decision due to spread information over a wide set of instruments for different inputs;
- low ergonomic care for the drilling chef personnel working in exposed and difficult position.

The issued software oriented monitoring system improves the total performances of the traditional drilling rig control system using the flexibility of a PLC based monitoring system with a LabVIEW designed software environment for computer level human interaction. Figure 2 describes the principle of a drilling installation monitoring starting with the heavy equipment level (on the bottom), going up to the programmable logic (PLC) and supervising software.

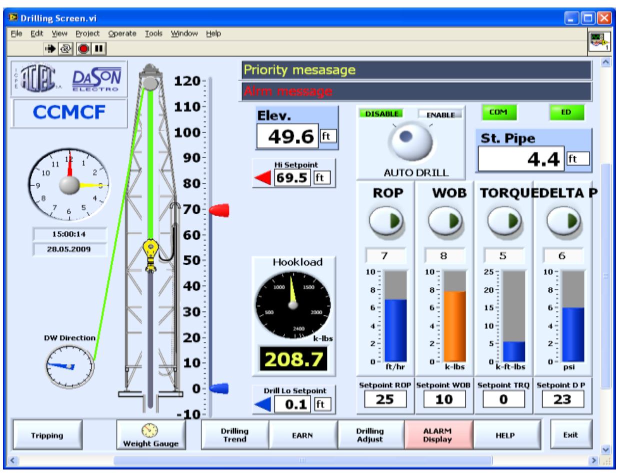

Fig.2. Computer based monitoring of a drilling rig.

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The design target is to integrate the standard control desk into a computer based framework allowing monitoring and control of the drilling process parameters, saving data and commands into a database providing events and alarms management and a virtual black-box of the rig to improve the protection level of this complex equipment. All these can be obtained using a command controller for drilling software based on:

- LabVIEW virtual instruments – console equipment to replace the existing devices on the drilling platforms allowing friendly use functions to human operator for the most important drilling parameters;
- reliable fiber optic communication;
- PLC interface with connected equipment and sensors.

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

2.2. Parameters to be monitored

Besides monitoring drilling parameters the project is designed as an open system ready for future developments to allow complete control and future automation over drilling installation [10], [13], [14].

The equipments which are monitored at this stage of development are (as illustrated in figure 3):

- Diesel generators having 1500kVA at 600V;
- Connection switches to main power supply distribution used by generators;
- Motor drive converter;
- Connection switches to main power supply distribution used by converter;
- excitation converter for motors;
- Connection switches to main power supply distribution used by excitation converters;
- Connection switches to auxiliary power supply distribution used by transformers;
- Electrical drive motors status (visual symbols).

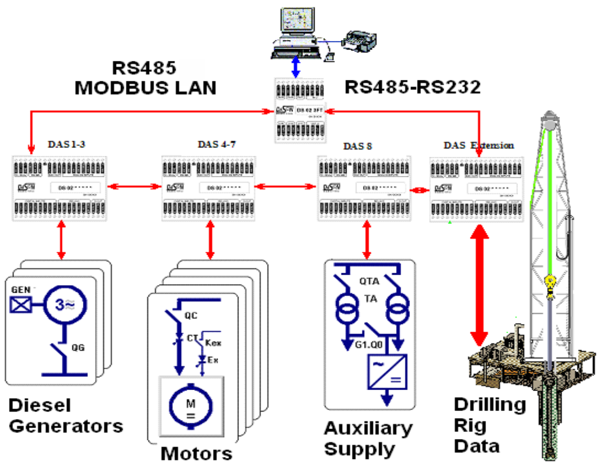

Fig.3. Drilling process monitoring.

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

2.2.1. Monitoring hardware equipment

The number of inputs for the monitoring system is dictated by the general design of the drilling rig dictates. Two main parts are actually important for the study: the Diesel generators forming a local power plant and the numerical drives for rigs power motors. These are connect to the monitoring system using a PLC, as shown in figure 4, for the power plant, and an additional PLC for the numeric drives and motor state sensors .

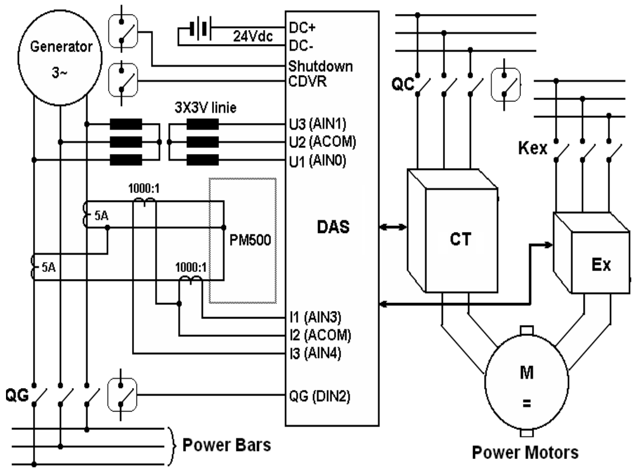

Fig.4. Driving motors and generators data acquisition system.

2.2.2. Monitoring software

The software interface for electrical drive equipment monitoring has generally two different parts [15], [16]:

- Software designed for execution system processors which is responsible for data acquisition process;
- Software resident on the application host computer which allows data communication, real time data processing and storage, control of the application and the management of events and alarm system.

The main window of application control system is shown in figure 5. A graphic synoptic of the rig provides the operator with global information about how the system works, as may be seen in various windows oriented on the main functional blocs of the drilling rig: Diesel generators, numerical drives (CCR), draw-works, mud pumps, rotary table and lifting pumps.

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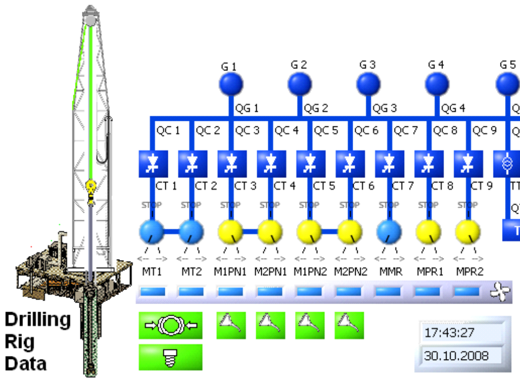

Fig.5. Main window of the monitoring application.

The application panel backup in LabVIEW is the software graphical diagram in figure 6.

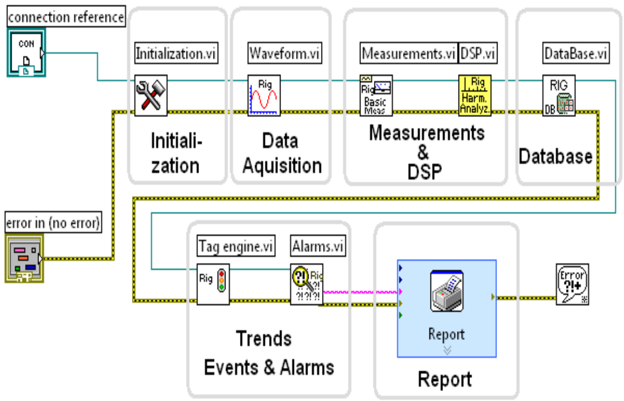

Fig. 6. LabVIEW application software diagram.

Six main block in the software diagram power the application:

- Initialization- responsible for hardware and software setup;
- Data acquisition- bringing data to the central processing unit;
- Measurements and DSP- performing basic measurements of the system parameters and advanced digital analyses of data;
- Database- on line storage of data, trends and events;
- Trends, events and alarms- the SCADA like environment for the rig
- Report- report generator and state publisher on the net using secured protocols.

Browsing the equipment icons on the main window of the application, operator can open additional state windows for the main parts of the rig. An example, as shown in figure 7, is the synoptic diagram of the numerical drive system, CCR, providing the actual state for the general electric schematic of the rig.

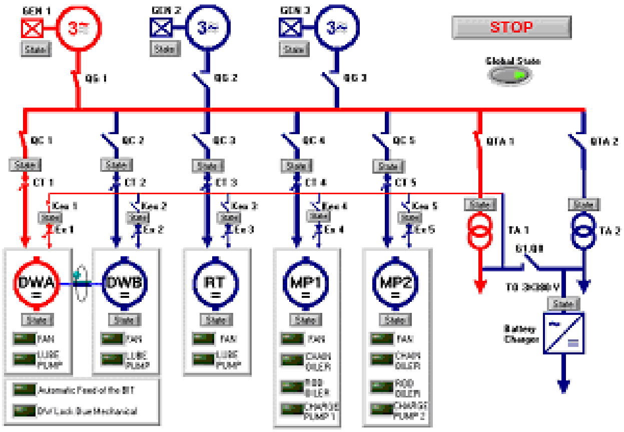

Fig.7. Software synoptic of the electric equipment on the rig.

In deep state information may is available activating one of the *State* buttons in the synoptic window. New monitoring windows will be displayed, accordingly:

- Figure 8. Diesel generators status window;
- Figure 9. Draw-works status window;
- Figure 10. Hook charge status window
- Figure 11. Mud pumps status window.

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

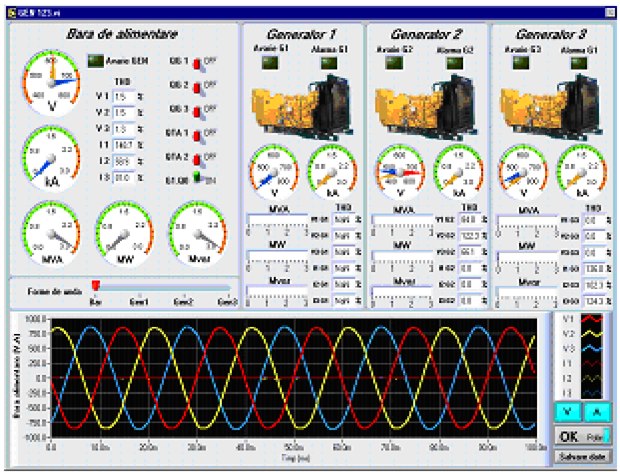

Fig.8. Diesel generators status window.

Diesel generator controls show electrical parameters such as: generators 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 schematic draw (left side of the figure) and intuitive functional symbols for each system.

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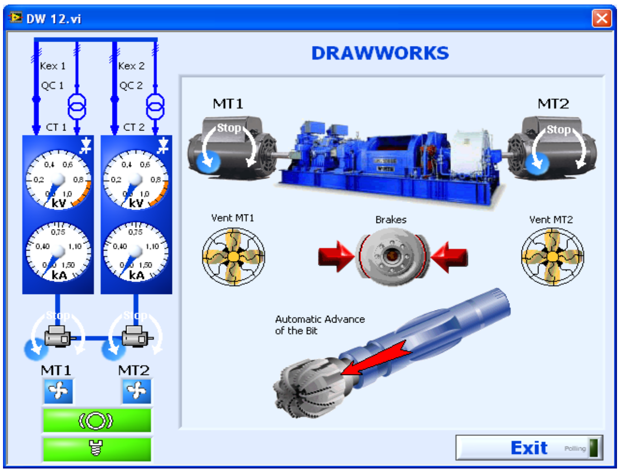

Fig.9. Draw-works status window.

Many of drawing elements from control windows are animated to increase efficiency and easy to use characteristics.
Draw-works are commonly designated by a horsepower and depth rating:

$$HP = \frac{W\ v_h}{33{,}000}\ \frac{1}{e} \qquad (1)$$

where W = Hook load, lb

v_h = hoisting velocity of traveling block, ft/min

33,000 = ft.lb/min per horsepower

e = Hook to draw-works efficiency

Hook to draw-works efficiencies are commonly between 80 to 90%, depending on the number of lines in use. The left side button allows global inspection of parameters at power supply level and each equipment status is shown in the right side of display.

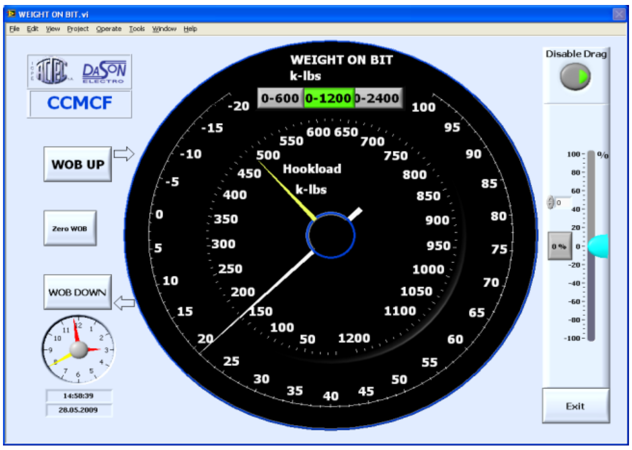

Fig.10. Hook charge status window.

Assuming that the system is frictionless, the following relationship is apparent:

$$F_d = \frac{n+2}{n} W \qquad (2)$$

where:
F_d = total compressive load on the derrick
n=number of lines through the travelling block (those supporting W).

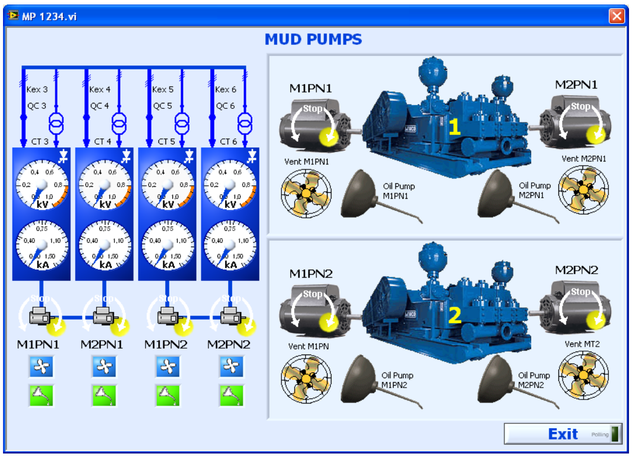

Fig.11. Mud pumps status window.

3. Conclusions

This intelligent monitoring system is based on SCADA architecture designed using LabVIEW software, using PLC connected to a mainframe server via MODBUS communication system on RS485 wire or fiber optic interface.
An intelligent monitoring and control system for both inland and offshore drilling platforms is no easy task to compute. Thus, distinct local drilling conditions must be taken into account.
The electrical parameters monitored must provide information about drilling process general status, about evolution of electrical parameters of drive motors involved in the process and about evolution of other parameters characteristic for drill process, like: mud pressure and temperature in different points of the system, drilling bit pressure, torque or drilling speed. All these information is surveyed, associated with events, trends and alarms and finally saved in a real time data management system allowing control and warnings at different levels, depending of their severity.

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