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A SYSTEM FOR MONITORING WELL LOGGING PARAMETERS

Daniel MIHAJLOVIĆ, Ivan MEZEI, Miodrag BRKIĆ,
Miloš ŽIVANOV, Miloš SLANKAMENAC
"Faculty of Technical Sciences" University of Novi Sad, Department of electronics, Trg D. Obradovića 6, 21000 Novi Sad, Serbia & Montenegro
miloss@uns.ns.ac.yu

Abstract. *Borehole measurement systems are used for measuring parameters in borehole exploration facilities. Measuring methods include the use of various sophisticated tools that are descended into boreholes. Various parameters are to be monitored in order to avoid damaging expensive equipment. These parameters include tool speed, depth, cable tension and tool tip differential tension. These parameters can be analized offline using log file. This paper presents a solution which meets the requirements for monitoring and displaying these parameters on the borehole site.*
Keywords: *Acquisition, Measurement system, Well, Logging, Monitoring.*

Introduction

Borehole measurement systems (see Figure 1) are used for measuring various parameters in gas, oil and other borehole exploration facilities [1]. A typical system for boreholes investigation has:

1. a Surface unit for analysis and monitoring of measurement results,
2. a cable for mechanic and communication link between logging tools, the surface unit and equipment for relocating tools, and
3. logging tools.

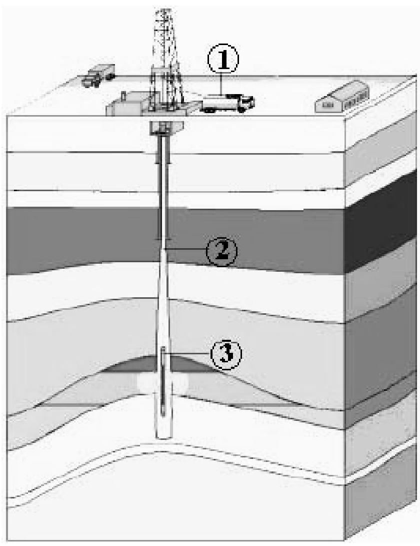

Figure 1. Borehole measurement system.

Measuring methods include the use of various sophisticated tools that are descended into boreholes up to 5 kilometers of depth. While tools are being descended into a borehole, various parameters are being monitored in order to avoid damaging of expensive equipment. These parameters include the tool speed, depth, cable tension and tool tip differential tension. The human borehole operator who manipulates the tool equipment should be aware of these values. The complete measurement and monitoring system is placed away from the borehole site up to 50 meters. This system is located in a cabin of a special motor vehicle in which a human operator can observe the measured data.

Nowadays there is a strong tendency of replacing analogue with digital well logging systems [2]. Digital systems for borehole measurement are capable of tracking more parameters at the same time than analogue systems. Using this advantage, the process of logging, overall time and costs can be reduced. Due to a larger number of sensors and electric devices for processing data and smaller dimensions of digital tools than analogue tools, the designing of mechanical parts and PCBs (Printed Circuit Board) is much more difficult. Digital logging strings are smaller, more reliable and more effective for processing and storing data than analogue logging strings [3].

This paper presents a solution for monitoring and displaying critical parameters on the borehole site that meets predefined requirements.

Problem description

Borehole measuring systems consists of a borehole and measuring equipment. Measuring equipment consists of several tools and the data acquisition unit. The tools together with the rest of the borehole equipment are located on the borehole site while the data acquisition unit is placed away from the borehole site and located in a so-called surface unit (usually a truck). Surface unit consists of necessary equipment to descent the tools into the borehole and to monitor and acquire various data. Typical borehole system is depicted in Figure 2.

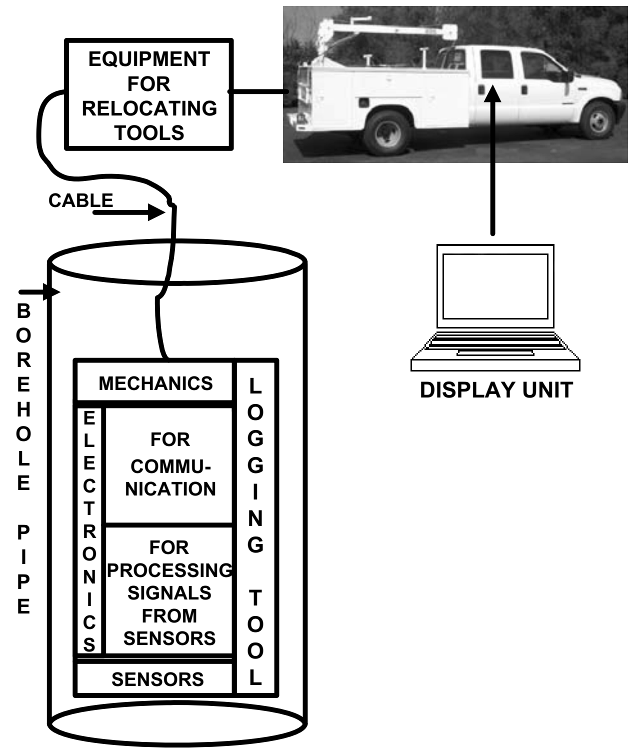

Figure 2. Typical borehole system.

While the borehole equipment containing tools descends, the data acquisition unit collects and stores various data from the tools, usually on a notebook computer. The acquired data are used afterwards (offline) for various calculations that are a valuable input in analysis of geophysical properties of the borehole. During the measurement process, some of the acquired data are crucial and indicate unexpected behavior that can lead to the damage of the equipment or some other sort of a hazard [4].

Problems arise if borehole operators do not have access to critical data being acquired in the surface unit thus being unable to take appropriate and on - time actions in case of an unexpected system behavior occurs. Values that indicate potential tool, cable or other measuring equipment damage due to an unexpected behavior are tool cable tension and tool tip differential tension. If any of these values exceed the operating range, some kind of equipment damage might occur. The other values can also help borehole operators to avoid potentially hazardous situations. These are tool depth and cable descent speed. If one of these values starts to change (or even freeze) unexpectedly, operators can conduct standard procedure to prevent eventual damage. To avoid these hazardous situations, borehole operators must have these critical values displayed in their visibility range.

Due to the specific working conditions in the cabin, audible indication of critical parameter excess is required. Another issue is data recording (in case of power loss or when offline analysis is needed). Therefore, the system should be equipped with battery backup (UPS), while actual data is stored in the microcontroller EEPROM.

Solution

A solution presented in this paper is part of the system depicted in Figure 3. System is designed as a robust display device, equipped with operator's HMI (human to machine interface).

Input digital and analog signals are collected in the interface block. The interface block distributes the signals to the appropriate analog and digital blocks. The digital block is used to process input signals from the external encoder and the interface keypad. In addition, the digital block communicates to the PC motherboard through the RS232 serial interface using a specific communication protocol. The essential part of the system is embedded PC hardware. PC - based software controls the monitoring process (data storing, HMI refreshing, peripheral blocks polling).

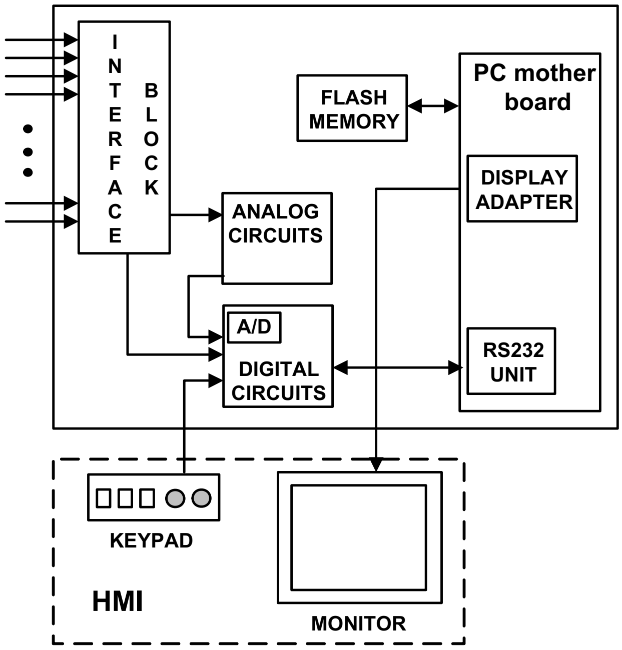

Figure 3. Measuring and monitoring system.

The purpose of the HMI block is to enable operation between human operators and the monitoring system. HMI block consists of two main devices: a TFT display and the interface keypad. The fifteen-inch TFT display is chosen for this application as a good trade-off, having in mind the operating conditions, price, reliability and functionality. Additional protective glass is mounted in front of the display to increase dust and shock immunity. The main drawback of the current TFT technology is the low visibility angle which can be neglected by the fact that position of the operator's seat remains constant during the operation.

The interface keypad is used to set the required values of monitoring parameters. Initial depth is set by pressing thumbwheel buttons for each digit (Figure 4.). When a desired initial depth is set, the accept button (F2) must be pressed. The reset button is used to set initial depth to default (0 m). Rotational knobs are used to adjust MMD (magnetic mark detector) and CCL (colar case locator) gain, having in mind the variety of measuring tools. Start and stop log buttons are pressed in normal operation at the begining and the end of the well logging process.

The signal interface block is used to collect and interconnect external signals from the incremental encoder, tension transmitter, MMD and CCL pick-ups to digital and analog blocks.

The analog block consists of three separate channels (tension signal, CCL, MMD). Each one of them provides necessary gain, input and output impedance and frequency response.

Figure 4. Interface keypad.

The tension signal channel transforms input miliamper signals (4-20 mA) into appropriate voltage signals that can be efficiently converted into digital ones using a 12 bit A/D converter. The A/D converter circuit is a part of the digital block. The tension channel is realized as a two-stage amplifier circuit. The first stage is a differential amplifier with an operational amplifier. This topology provides a high CMRR necessary for milliamper signal conversion. Second stage is a common inverting amplifier.

The MMD signal channel transforms input voltage signals into voltage output that is multiplexed and converted into digital signals using a 8 bit A/D converter. The CCL signal channel transforms input voltage signals into voltage output that is multiplexed and converted into digital ones using a 8 bit A/D converter.

The digital block consists of the microcontroller, two A/D converters, digitally controlled analog multiplexers, digital multiplexers and other passive components.

PC hardware block

What is used here is a standard integrated micro ATX motherboard with a processor, RAM modules and a IDE flash-memory. Standard hard disk drives are rather inappropriate for harsh environment applications. Its sensitivity to vibrations and increased temperature makes the hole system unreliable. The IDE compatible flash drive is chosen to replace the standard

HDD. Its low weight and its fully electronic design makes it suitable for use in robust systems.

The PC application software is responsible for serial communication with the microcontroller and for displaying the received data through GUI on TFT display (Figure 5.). In addition, all monitored data should be recorded and saved as a file, which can be displayed graphically and analyzed when necessary. This feature is of great significance in case of an investigation process after the equipment damage and other well-logging problems. The application software is created in the MS Visual Studio, in C# programming language.

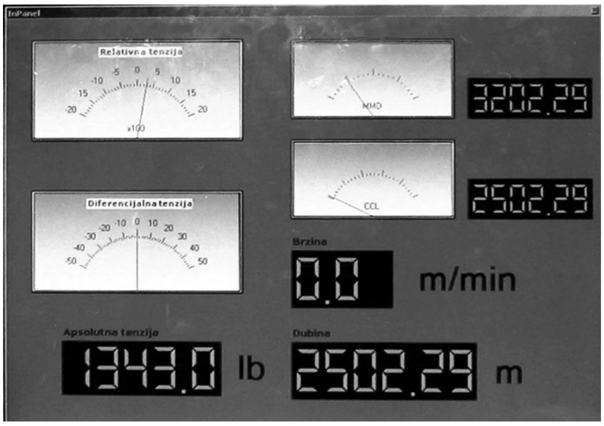

Figure 5. View of displayed parameters on TFT monitor.

The GUI elements are: **Depth** (defined by the incremental encoder) is displayed on TFT monitor with 4 main digits and two decimal digits. The range of the displayed depth is 0000.00 m to 9999.99 m.

Velocity is displayed with two main digits and one decimal digit. The range of the displayed velocity is 00.0 m/min to 99.9 m/min.

Magnitude of **MMD** signal is presented as deflection of simulated gauge, and equivalent depth of the last MMD pulse with digit display.

Magnitude of **CCL** signal is presented as deflection of gauge, and equivalent depth of last CCL pulse with digit display.

Absolute tension is displayed by 4 main digits and one decimal digit. Differential tension is displayed by the two gauges. The lower one displays velocity of difference in absolute tension in range of -50 lb to +50 lb.

Relative accumulated differential tension is displayed by the upper gauge, and deflects only when the lower gauge reaches its limit.

The final product has been designed at the Department of electronics, Faculty of Technical Sciences in Novi Sad. The final product is currently being used in NIS Naftagas, a petroleum company from Novi Sad, Serbia and Montenegro, as a part of horizontal borehole exploration equipment.

Concluding remarks

This paper presents a solution to the problem of monitoring and displaying critical values in borehole measurement systems in order to prevent hazardous situations that might lead to equipment damage. To avoid such situations, borehole operators must be aware of critical parameters such as speed, depth and cable tension. The solution enables offline analysis after logging completion.

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