In-Drilling Alignment Apparatus for Measurement-While-Drilling Processes

Alexander Djurkov, Justin Cloutier, Efraim Pecht, Martin P. Mintchev
Department of Electrical and Computer Engineering, Calgary, Alberta, CANADA

Outline

1. Introduction
2. Motivation
3. Inertial Navigation System
4. Overview of In-Drilling Alignment
5. In-Drilling Alignment Apparatus Design
6. Experimental Results
7. Conclusion

Introduction

- Industry currently utilizes magnetic sensors to determine the azimuth angle of the bottom hole assembly while drilling.
- An inertial navigation system (INS) based apparatus is proposed to decrease the azimuth error during the directional drilling process.

Motivation

- Magnetometers are affected negatively by:
  - randomly located ore deposits
  - magnetic interference from the drill string and drilling fluid
- Magnetometers are insolated from magnetic interference by lengthy nonmagnetic collars
  - adds weight and cost to the MWD tool
  - some near-drill bit rotations are unnoticed

Motivation

- Improve the current borehole surveying accuracy by utilizing an INS-based surveying system
- Reduce the overall cost of Measurement-While-Drilling (MWD)
- Increase production from reservoirs by accurately placing the wellbore

Inertial Navigation System (INS)

- Consists of three mutually perpendicular accelerometers and gyroscopes
- Calculate real-time velocity and position by integrating acceleration
- Calculate real-time roll/pitch/azimuth by integrating rate of turn

Fig. 1 LN-200 Inertial Measurement Unit

Disadvantages of Traditional INS

- Unlimited error growth with surveying time is observed in the position and attitude due to the integration of biases incorporated in the accelerometers and gyroscopes.

Overview of In-Drilling Alignment

- In-Drilling Alignment (IDA) is an algorithm that utilizes a non-stationary reference measurement to reduce the estimated azimuth error.
- The IDA algorithm can be performed within the drill string when the drill bit is idle.

Overview of In-Drilling Alignment

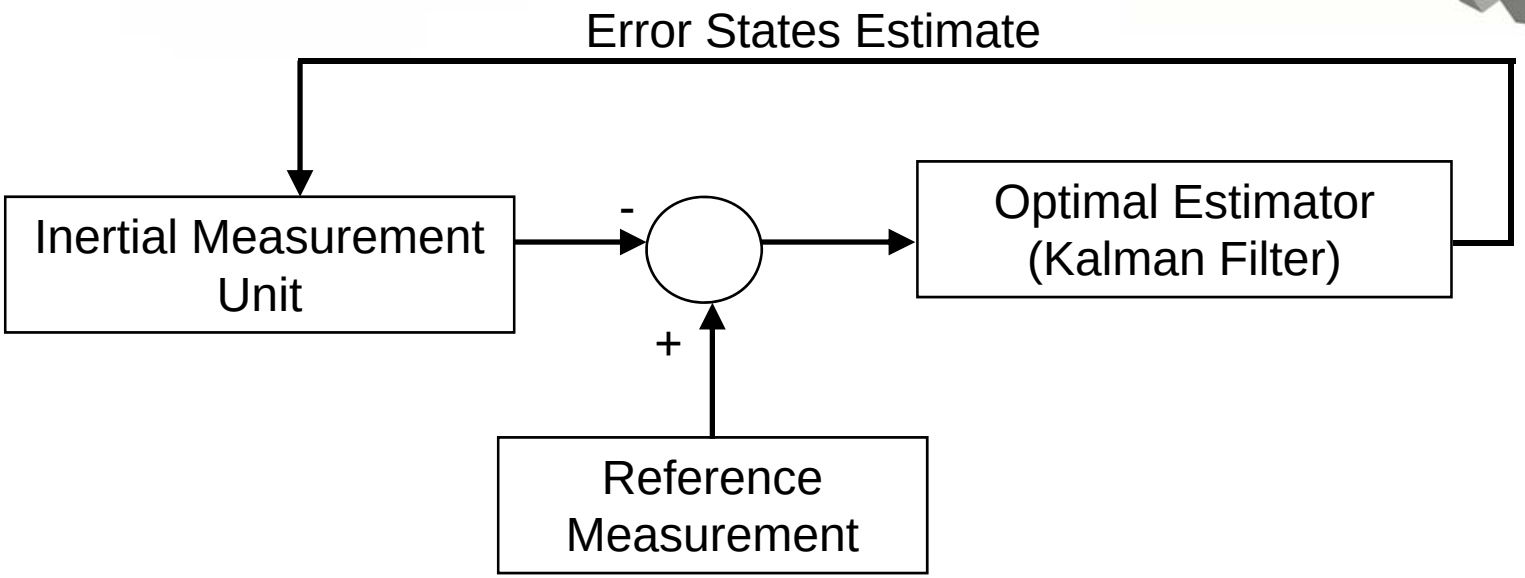


Fig. 2 Schematic of IDA

Overview of In-Drilling Alignment

- A controlled motion is induced on the inertial measurement unit (IMU) to provide a non-stationary reference measurement.
- The induced motion provides a strong force in the horizontal plane (azimuth), while gravity provides a strong force in the vertical plane (pitch and roll).

IDA Apparatus Design – The Inertial Measurement Unit Capsule

Capsule Contains:

- Inertial Measurement Unit (IMU)
  - Three mutually perpendicular accelerometers
  - Three mutually perpendicular gyroscopes
- Radio Frequency (RF) Transmitter
- Long-life rechargeable battery

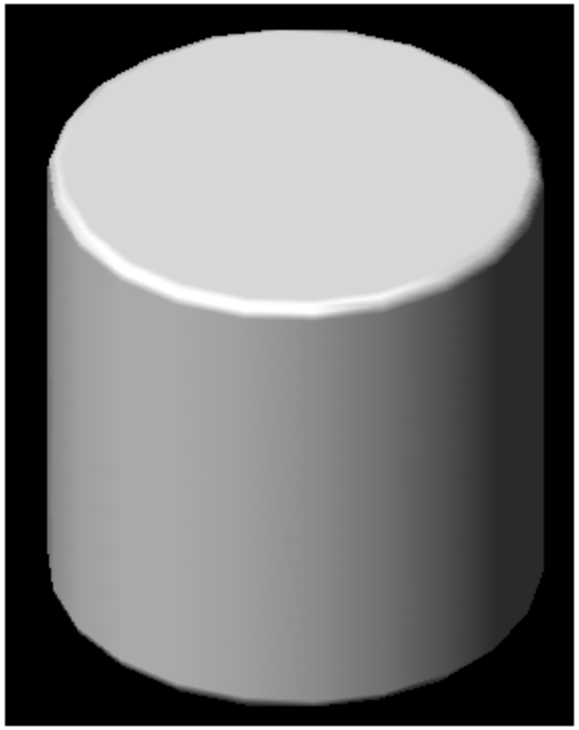


Fig. 3 IMU Capsule

IDA Apparatus Design
The Capsule

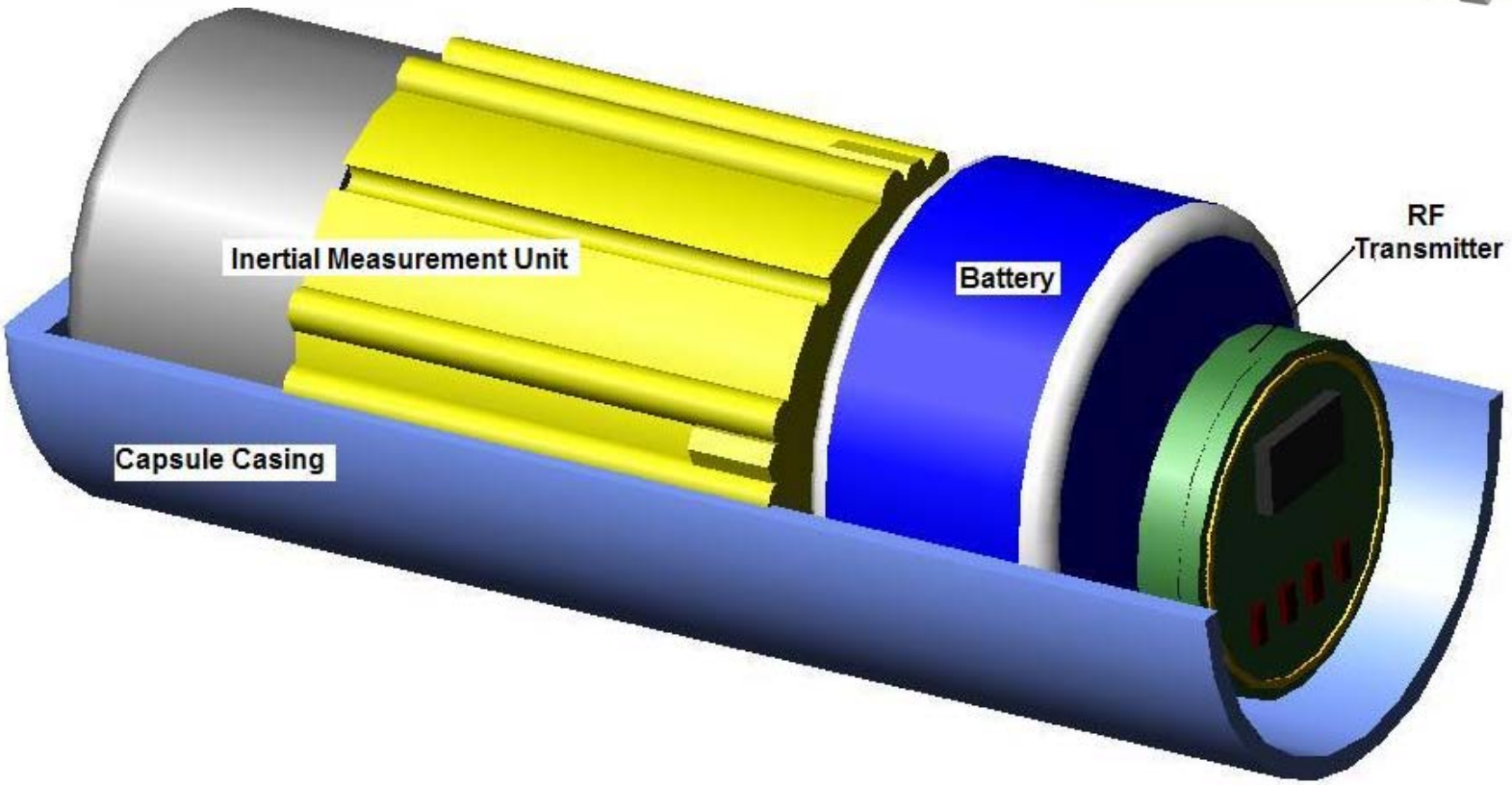
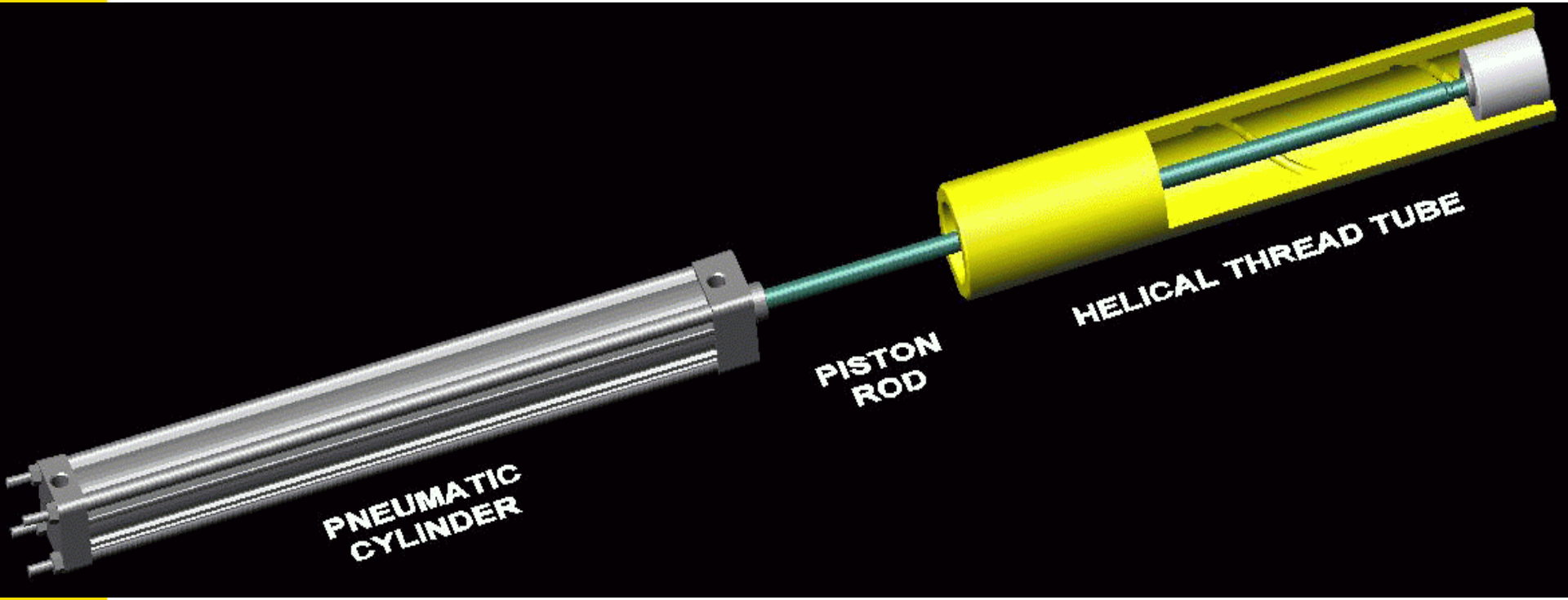
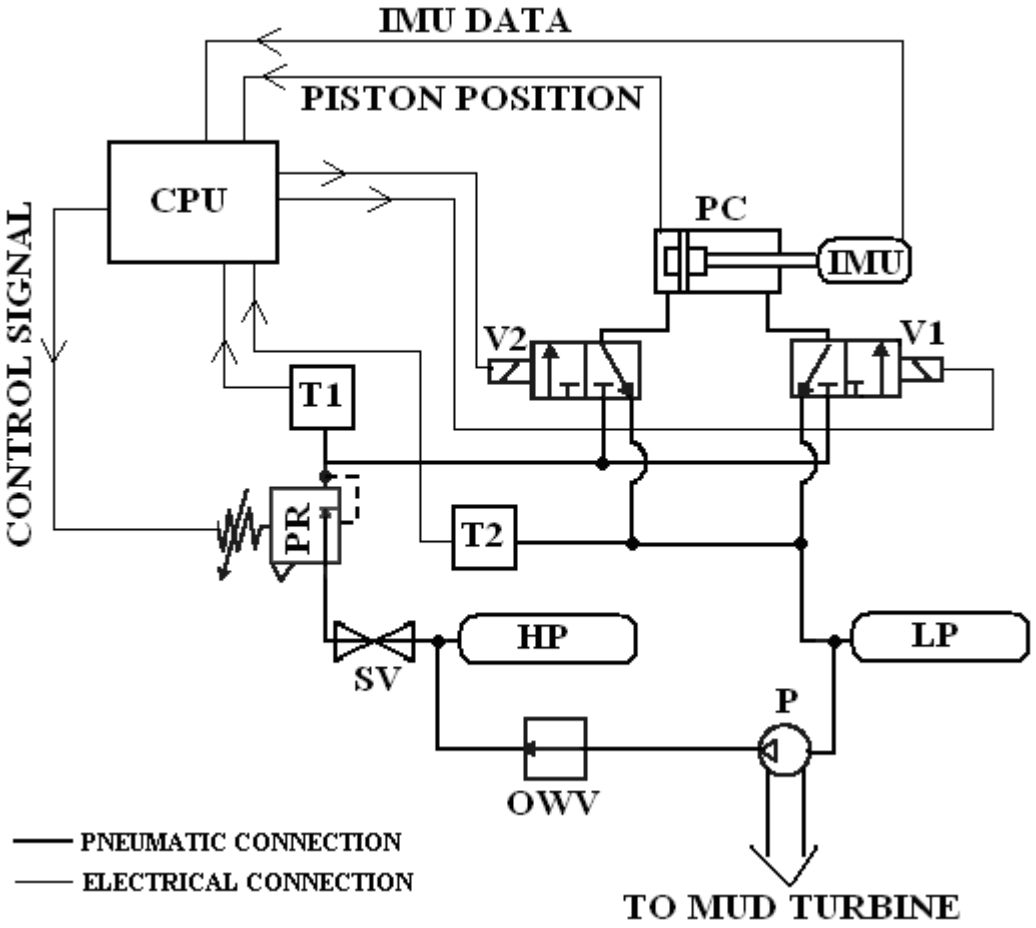


Fig. 4 Schematic of IMU Capsule Internals

IDA Apparatus Design - Inducing Motion on the IMU



IDA Apparatus Design - Pneumatics



CPU – Central Processing Unit

PC – Pneumatic Cylinder

V1/V2 – 3 Way Solenoid Valve

T1/T2 – Pressure Transducer

PR – Pressure Regulator

HP – High Pressure Air Tank

LP – Low Pressure Air Tank

SV – Shutoff Valve

OWV – One-way Air Valve

P – Air Pump

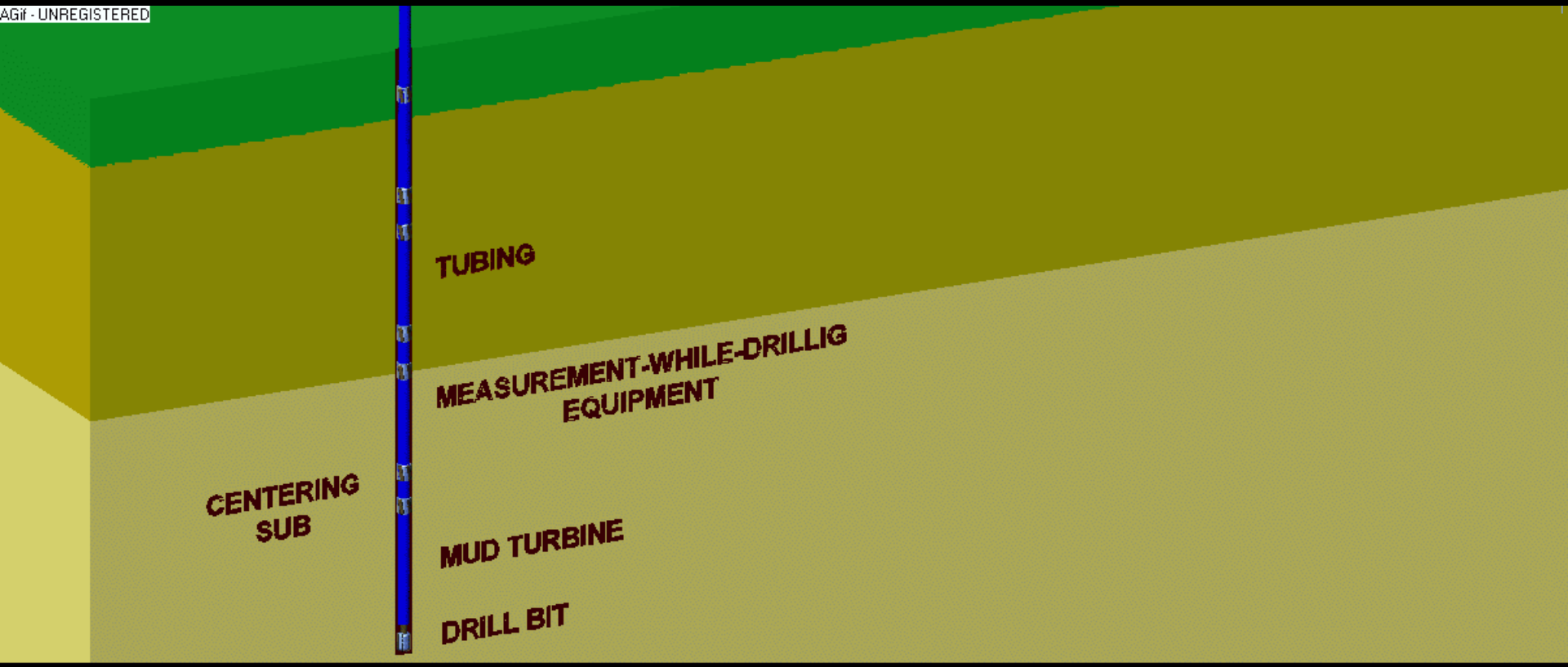
Fig. 5 Schematic of IDA Pneumatic Components

IDA Apparatus Experimental Results

Table 1 – IDA Error versus Magnetic MWD Error

Azimuth Angle [Degree]	Magnetic MWD Model [Degree]		IDA Method [Degree]	
	Estimated Error[1]	Standard Deviation[2]	Estimated Error	Standard Deviation
75	0.837	1.5	0.019	1.45
85	0.868	2.0	0.281	0.97
95	0.889	2.0	-0.0256	1.42
105	0.896	1.5	0.00215	1.21

1. Williamson H.S.: “Accuracy prediction for directional MWD” In: Proceedings of the SPE Annual Technical Conference and Exhibition, Houston, TX, pp: 637-652, Oct 3-6,1999.
2. Nyrnes E., Torkildsen T.: “Analyses of the accuracy and reliability of magnetic directional surveys” In: Proceedings of the SPE/IADC Middle East Drilling Technology Conference and Exhibition, Dubai, United Arab Emirates, pp: 35-54, Sep 12-14, 2005.


AGif - UNREGISTERED
TUBING
MEASUREMENT-WHILE-DRILLIG EQUIPMENT
CENTERING SUB
MUD TURBINE
DRILL BIT

Thank you for your attention.

Alexander Djurkov, Justin Cloutier, Efraim Pecht, Martin P. Mintchev
Department of Electrical and Computer Engineering, Calgary, Alberta, CANADA