

An Overview of DOE Sponsored High Temperature Tool Development at Sandia National Laboratories

HADES Workshop

May 25-26, 2011

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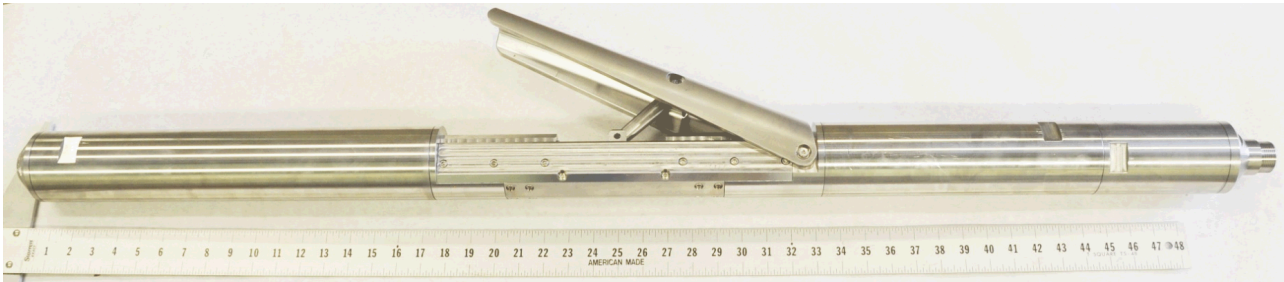




Sandia's High Temperature Tool History

- **TPS Dewared Memory Tool**
- **Spectral Gamma Memory Tool**
- **CTDL Memory Tool**
- **Fluid Sampler**
- **Televiwer (Joint with Navy, USGS and Mount Sopris Instrument Co.)**
- **DWD POC and HT Drilling Tool**
- **Memory Drilling Tools (For Unsen Scientific Drilling Program - Tohoku University)**
- **Dewarless PT Well Monitoring Tools (For NETL and USGS)**
- **280°C Analog PT Well Monitoring Tools (Chevron Steam Injection Wells)**
- **Seismic Tool**

High Temperature Seismic Tool



- **Capabilities**
 - Operation up to 210°C
 - Three-axis accelerometer measurements
 - 30 Hz – 1000 Hz bandwidth
 - 20 V/g sensitivity
 - 295 μ g – 165 mg measurement range
 - 256 kbps data rate over 5000 ft. of 7-conductor cable

High Temperature Seismic Tool Construction

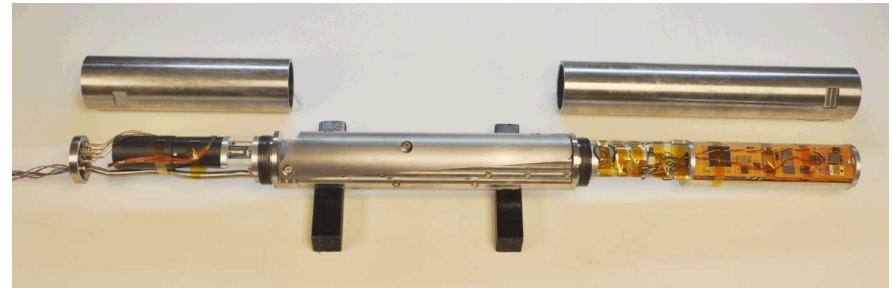
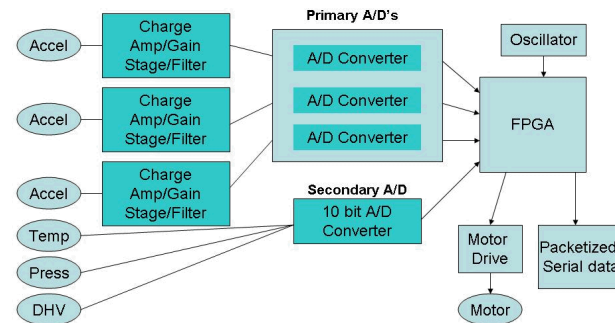
- **Electrical**

- All SOI electronics except FPGA and Primary ADC
- 24-bit ADC
- 8-pole anti-aliasing filter

- **Mechanical**

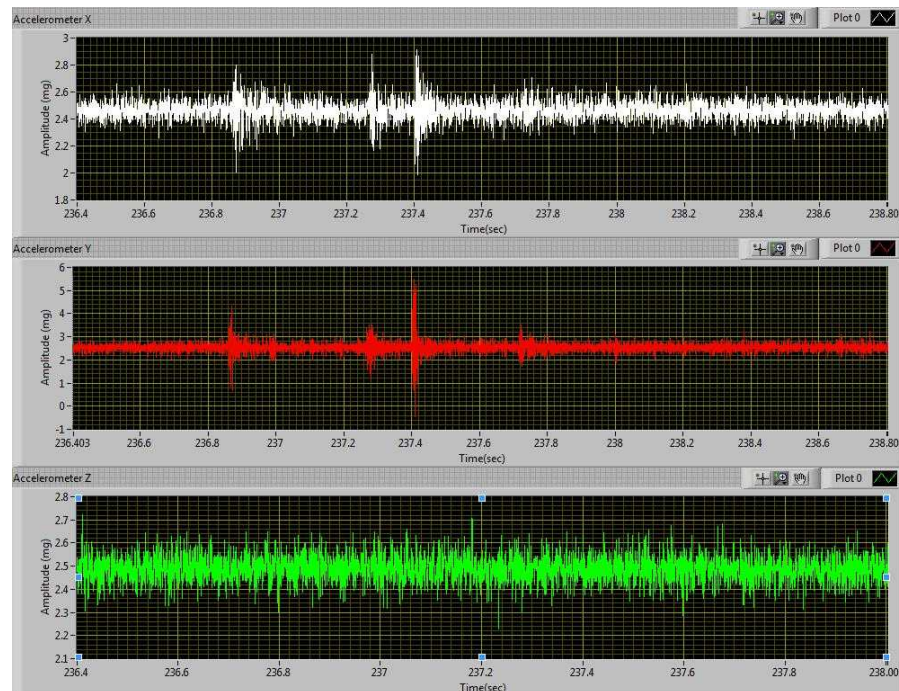
- All metal seals
- High temperature stepper motor for clamping arm drive
- Clamping arm capable of holding 600 lbs.

Seismic Tool General Layout



High Temperature Seismic Tool Testing

- Initial seismic tool testing has been performed at Desert Peak and Brady geothermal fields in Nevada
 - Short term tests up to 190°C
 - Longer term monitoring of stimulation testing at Desert Peak



High Temperature DWD Tool

- DWD is a system to provide high-speed, real-time downhole data to the surface for use by the driller and to archive this data for later post drilling analysis
- The DWD system is comprised of
 - Downhole tool
 - Communication link
 - Uphole electronics
 - Integrated Data Display System (IDDS)





DWD Capabilities

Primary Channels

(1040 Samples/Sec.)

- Weight on Bit (WOB)
- Torque on Bit (TOB)
- X bend (strain gage)
- Y bend (strain gage)
- Endevco accel X value
- Endevco accel Y value
- Endevco accel Z value
- X magnetometer
- Y magnetometer
- External pressure (annulus)

Secondary Channels

- Z magnetometer (62.5 S/s)
- Internal temperature (pipe) (62.5 S/s)
- External temperature (annulus) (62.5 S/s)
- Internal pressure (pipe) (62.5 S/S)
- PC board temp (on digital board) (62.5 S/s)
- Downhole voltage (62.5 S/s)
- Secondary accel X value (125 S/s)
- Secondary accel Y value (125 S/s)
- Secondary accel Z value (125 S/s)
- Internal pressure temp (62.5 S/s)
- External pressure temp (62.5 S/s)

DWD Field Testing



- **POC DWD Tool**

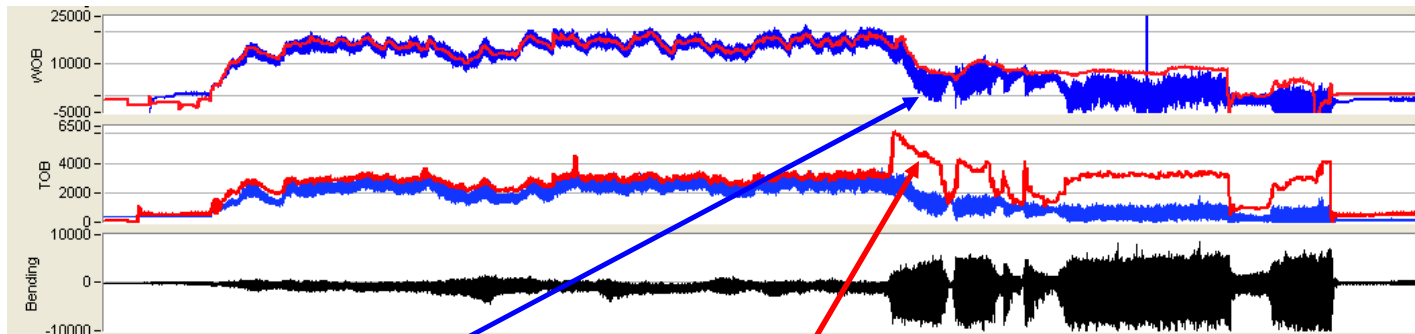
- Fielded several times in hard sedimentary and granitic formations, supporting CRADA bit programs with four bit manufacturers

- **HT DWD Tool**

- Partnered with ORMAT at Steamboat, Nevada, with no failures in a hard-rock geothermal environment

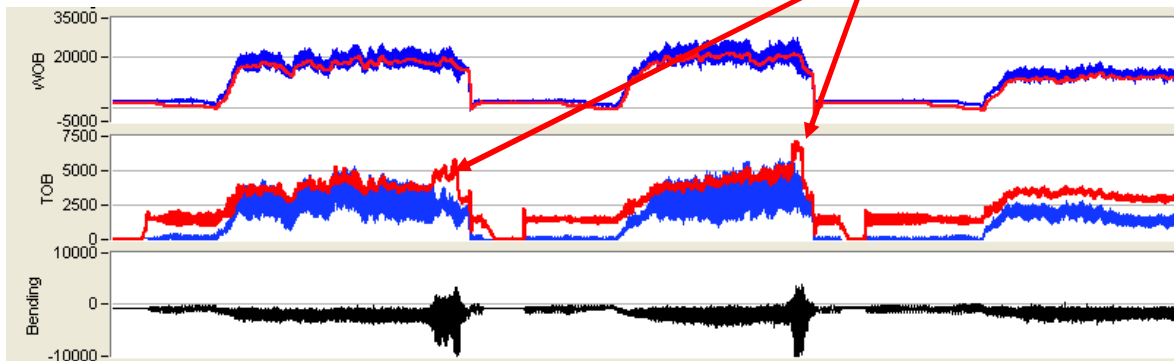
DWD Results

Detecting & differentiating whirl



Drill-off of WOB; bit bouncing

Torque jump implies whirl



No drill-off of WOB; no bit bouncing



High Temperature Base Technologies

- Develop building block necessary for robust tools that can operate in supercritical environments
 - Building blocks consist of MultiChip Modules (MCMs)
- Design and field test tools based on developed building blocks
 - 240°C Dewarless Pressure/Temperature/Collar locator (PTC) Tool
 - 450°C Dewared PTC tool
 - 450°C Fluid sampler (not currently funded)
- Collaborate with universities and industry to help solve the technical challenges detailed in this proposal
 - Packaging reliability
 - Interconnect issues
 - Improved Dewars
 - High temperature (HT) cables and batteries



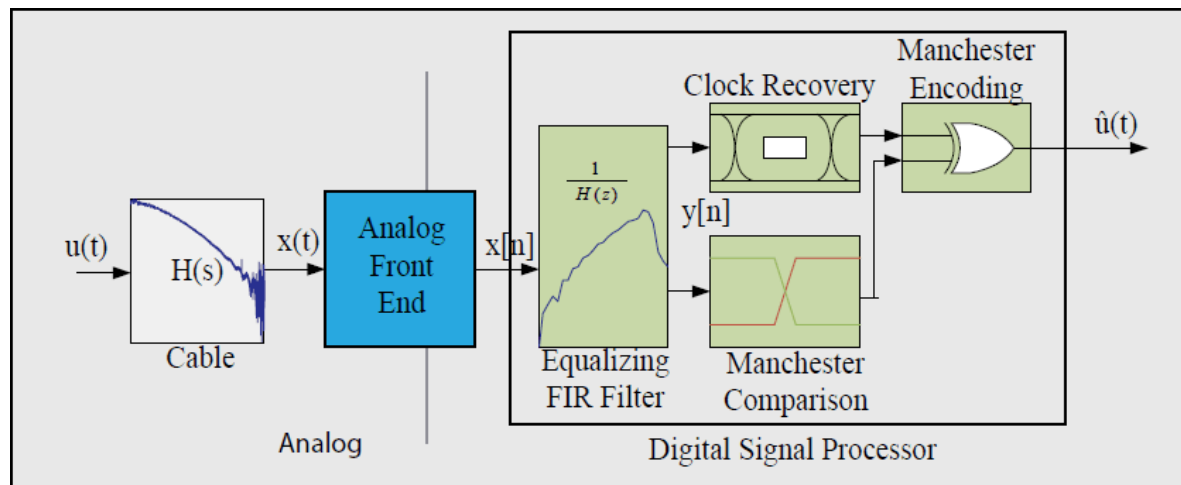
240°C PTC Tool (*development in progress*)

- **This tool utilizes all SOI electronics to measure pressure, temperature, and collar counter data**
 - **Second generation will include a spinner measurement**
- **Two field tests planned**
 - **The first test will be used to calibrate the CCL circuit**
 - **The second test will use a modified mechanical housing and electronics optimized from results of the first test**
- **Results from the second field test will enable design finalization and fabrication of the analog and digital MCMs**

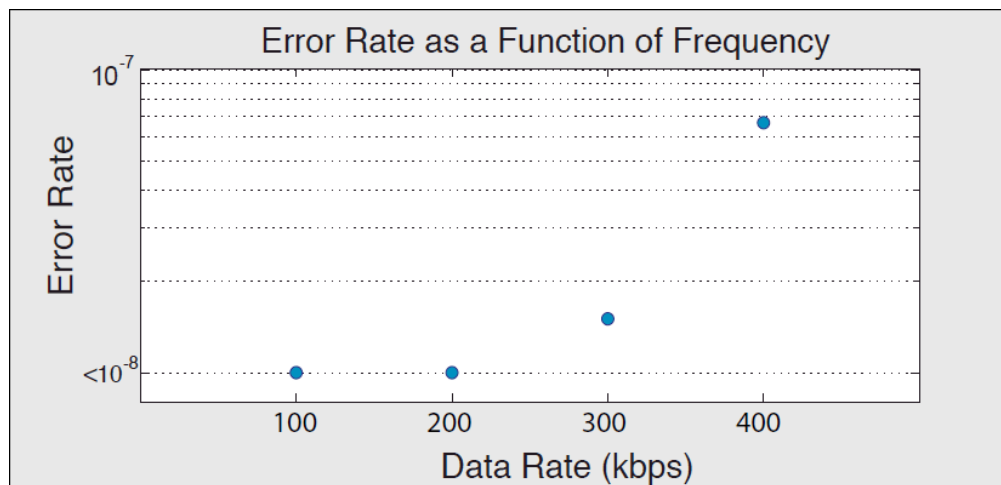
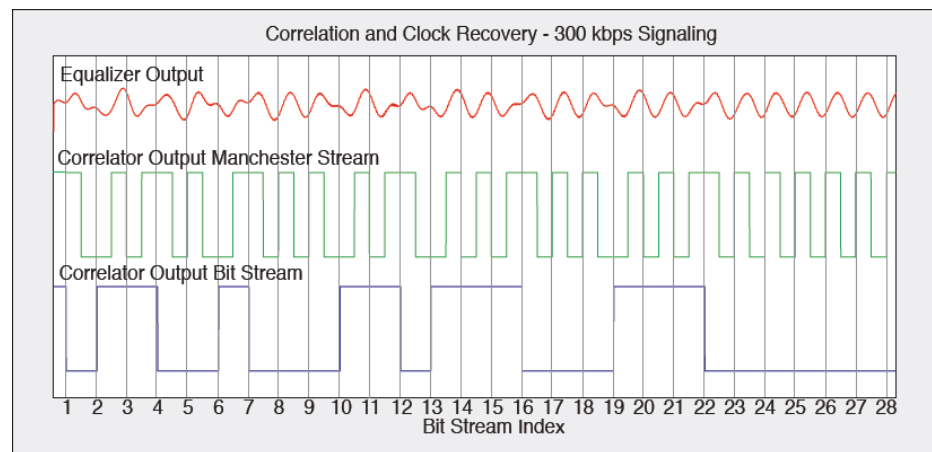
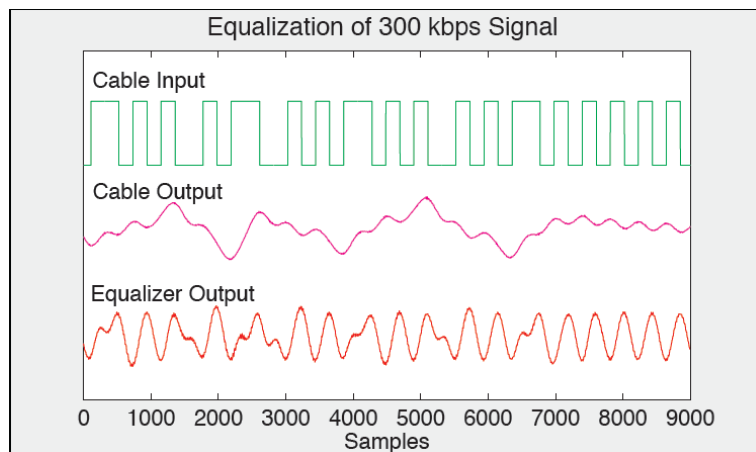


High Temperature Wireline Data Link

- Joint project between Sandia and Harvey Mudd College to increase the speed of high temperature wireline data links
- The focus of this project is to improve uphole receiver electronics
 - It is difficult to implement advanced modulation techniques using current high temperature electronics
- A prototype system has been developed that operates reliably at 400 kbps over 5000 ft. of single conductor cable

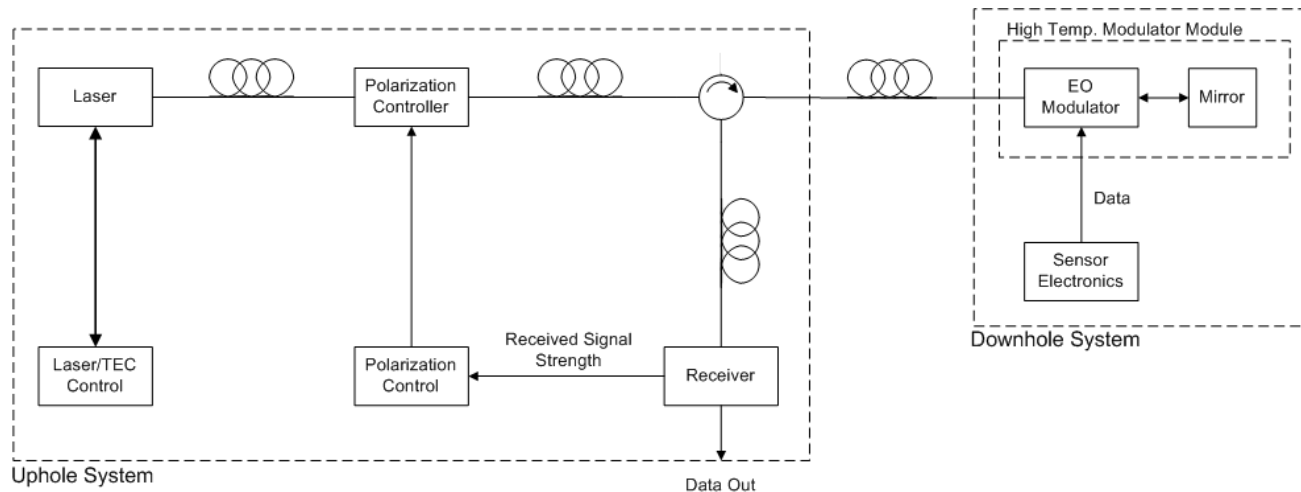


High Temperature Wireline Data Link Results



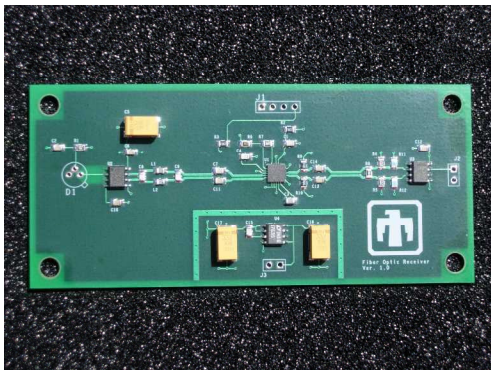
High Temperature Fiber Optic Data Link

- The goal of this project is to develop a > 1 Mbps high temperature fiber optic data link
- Data will be encoded onto the fiber optic cable utilizing an optical modulator illuminated from the surface



Fiber Optic Data Link Progress

- A low temperature version of the system has been build and demonstrated
 - Operates at speeds up to 10 Mbps
- High temperature packaging options for two different optical modulator technologies are being pursued
- A field test is currently scheduled for mid-2012





Questions?