Innovative Digital Instrumentation
For Geotechnical Monitoring

Andrew Hyett
YieldPoint Inc.

ME/MO CONFERENCE
“INNOVATIONS IN MINING”
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www.yieldpoint.com
Conventional Geotechnical Instrumentation

- Load cells
- Strain Gauges
- Piezometers
- Data-loggers

- Expensive
- Conservative design.
- Retrievable deployment strategies
- Designed for permanent civil structures
Analog Sensors: Limitations

- High Cost – especially for those products widely used in civil engineering

- Reliability??
  (i) mV output susceptible to water ingress
  (ii) potentiometers poor survivability after blasting

- Suspect Sensor Performance in dynamic mining scenarios
  (i) vulnerable lead-wires. 1 channel /wire
  (ii) Money spent protecting leadwires

- Esoteric analog data (V, mV, mA, Hz) needs to be converted into real world units

Today, 99% of geotechnical sensors are analog
The Digital Opportunity

Beyond Geotechnical field over last decade, design of instrumentation affected by two factors:

1. The ongoing revolution in computation and telecommunications

2. Explosion of sensor utilization in the automotive industry

A decade ago state-of-the-art sensing technology was largely confined to government, military and university laboratories. Today, low mass produced commercial components are the state-of-the-art.

More cost effective geotechnical sensors can be built using digital as opposed to analog technology
Point 1. Ongoing revolution in computation

**IBM - XT**
- Speed: 4.77 MHz
- RAM: 64k
- ROM: 64k
- I/O: RS232 +
- Cost: UKP1000-1500

**Micro-Controller (MCU)**
- Speed: 20 MHz
- RAM: 1K
- ROM: 8K FLASH
- I/O: UART (RS-232)
- Cost: $2-5

“Embedded Systems”
POINT 2: Transducers in Automobiles

5mm x 5mm

MEMS +/- 1.3g Accelerometer

$10-25 (in Qty)

MEMS +/- 1.3g Accelerometer
Digital Sensors Architecture

= 2. Transducers + 1. MCU +/− RF Transceiver
MCU Tasks: Conversion + Filtering

1. Units conversion:

\[ \text{Tilt (arcdeg)} = \sin^{-1}(g) \]

<table>
<thead>
<tr>
<th>g</th>
<th>deg</th>
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<tbody>
<tr>
<td>0.00</td>
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<td>30.00</td>
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<tr>
<td>0.75</td>
<td>48.60</td>
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2. Digital Signal Processing (DSP):

Take 10,000 readings over 2s period and average

- Reduce noise floor
- Increase effective resolution

3. Output Signal

Transmit Standard Digital Output Signal
TILT (Tilt, Inclination, and Leveling Technology)

Static Application:

Dual Axis TILT-SG sensor

- Sill Mat monitoring
- Crown pillars
- Brow monitoring
- Roof monitoring

Range +/- 30 arcdeg. Res. 0.01arcdeg

Dynamic Application:

Biggest Opportunity: Seismic monitoring over mine communications system. Low cost Digital wireless micro-seismic Systems (5kHz bandwidth)
DETECT - Digital Extensometer Technology using Eddy Current Transducers

Measurement of movement around underground excavations is the most fundamental indicator of instability.

DETECT-GMM
<40% price of Pot. GMM

DETECT-6EX
<50% price of SMART MPBX

DETECT-CABLE
Patents Pending
MCU Task: 3. Linearity Correction

\[ y = 1.000x \]
\[ R^2 = 1.000 \]

\[ y = 1.0039x \]
\[ R^2 = 0.9996 \]
7 Reasons Why Digital Sensors are Better

1. Improved Accuracy (i.e. Linearity)
2. Improved Reliability (e.g. non-contact)
3. Output in Real World Units. All digital sensors have standard readout signal.
4. Output signal includes SensorID+ SensorType
5. Many channels on a single wire.
6. Simplified Low-cost Peripherals (e.g. Dataloggers)
7. Simplified Data Transmission (ESG Seismic System, MRS leaky feeder, EI-Equip leaky feeder)
8. Simpler Data Management
Peripheral devices communicate with digital sensors and display, store or transmit data.
SLUG – Sensor Logger for UnderGround

Key Points:

Simple:
Parse data to memory

No Configuration:
Recognizes sensor type
Plug ‘n Play

Low power consumption:
100 days at 1 rdg/hr
½ year at 1 rdg/day

Low Cost:
20% (i.e. 80% less) cost analog data-loggers
DESTINY

Digitally Enabled Sensor Transducer + Instrumentation Network by Yieldpoint

Network sensors + Interface with existing mine communications Infrastructure

DESTINY RF SLAVE

• 10 RF channels between 433 and 434MHz
• Open Air Range of 200m
• 9600 baud rate
• Wired version: mulidrop RS485 enabled
• Modbus ASCII Protocol
• Ethernet Option also available

Cost Effective: compared with $1000’s spent protecting lead-wires
64 Sensors/512 Channels of Conventional Instrumentation over 1 seismic channel
DATA IS ALREADY IN REAL WORLD UNITS

- No need for transformations, temperature compensation
- Feed data directly into structured Database
- Monitor Trends in the data and compare with alert thresholds
- When alarms triggered e-mail alerts
- FTP offending data to internet server (HTML + XML)
- Data viewed by technicians, engineers, consultants
MineScape: DataBase (not Spreadsheet) Oriented

Instrument ID: MINEID-04037110

Select Sensor:
- MINEID- 0403 71 10
- Family: DETECT
- Model: 6EX
- Type: 71

Filter installed Sensors:
- Do Not Show Destroyed Sensors
- Filter By Level: 5544
- Filter By Location: 
- Filter By Install Date: Start Date: End Date:
- # of Instruments: 1

Filter database by Date, Level and/or Location
Installation Location + Date:

- **Level:** 5544
- **Location:** 2 W Corage
- **Borehole:** A 2
- **Install Date:** 20-May-04
- **Installed By:** KJH

Node/Anchor Configuration:

- #1: 10.0 m
- #2: 8.0 m
- #3: 6.0 m
- #4: 4.0 m
- #5: 2.0 m
- #6: 1.0 m
- #7: N/A
- #8: N/A
- #9: N/A
- #10: N/A

- **Head at collar of hole**

**IMPORTANT:** #1 > #2 > #3... etc.

**Purpose:**

To monitor the back above cracked zone in shotcrete.

**Notes:**

Good installation. 0.40 w:c grout
MineScape 4. Temporal Plot

Graph showing temporal displacement data for different depths (10.0m, 8.0m, 6.0m, 4.0m, 2.0m, 1.0m) from 18 May 2004 to 17 June 2004.
MineScape: 8. Peripherals

SLUG Datalogger:

**STEP 1: Select Serial Port**

**STEP 2: Enter a Date/Time**

Start (Connect) Date + Time:

Finish (Disconnect) Date + Time:

13-Oct-04  13:34

**STEP 3: Select Action**

- Extract SLUG Data
- Erase SLUG Data
- Configure SLUG

**STEP 4: Download Data**

- SLUG ID:
- # Samples:
- Period (Hrs):

**STEP 5: View --> Add**

- # of CSVs:
- All Sensors
- Sensor ID = 10

SensorSync PalmOS:

**Sync Datasheets:**

- All Sensors
- MINEID-04037110

**Install Conduit:**

This action only needs to be performed once. It adds the MineScape conduit to the list in Hotsync manager.
MinesCAPE: Configure Slug?

**SLUG Datalogger:**

**STEP 1: Select Serial Port**

- COM1

**STEP 2: Enter a Date/Time**

- Start (Connect) Date: 13-Oct-04
- Start Time: 13:34
- Finish (Disconnect) Date: 
- Finish Time: 

**STEP 3: Select Action**

- Extract SLUG Data
- Erase SLUG Data
- Configure SLUG

**STEP 5: View --> Add**

- All Sensors
- Sensor ID = 10

**SensorSync PalmOS:**

**Sync Datasheets:**

- All Sensors
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This action only needs to be performed once. It adds the Minescape conduit to the list in Hotsync manager.

- Install Conduit

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**NOTE:**

Please ensure that the correct serial port is selected and the dates and times are entered accurately. The conduit installation should be done only once to avoid any additional configurations.
Digital sensors are typical 40-60% less expensive than analog sensors with even bigger savings in overall cost.

Low cost peripheral devices integrate geotechnical sensors into the digital mine.

Data transmission over leaky feeder (MRS, El Equip) or MAN (ethernet) is routine. E-mail alerts + data uploaded to internet.

Data integrated with ESG seismic system.

YieldPoint seeks mining operations to demonstrate Case Studies for this new exciting technology.