

Distributed Acoustic Sensing Applications in Downhole Fiber Optic Monitoring and Surveillance

Presented by 萬業科技 | OlitGlobal Technologies.

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- 萬業科技立基於台灣高雄,專注在「分布式光纖感應系統(DFOS)」的技術推廣。
- 核心能力為「系統規劃設計、光纖工程安裝、監測數據解析、儀器測量服務」。
- 團隊成員均有多年光纖監測經驗, 擅長於光纖光學、系統整合與應用發展。
- 長期與國內外客戶與夥伴合作,系統應用於土木、軌道與重要結構的工程, 在台灣市場經營及發展已有多項良好實績。







- Carbon Management Canada (CMC CaMI Field Research Station)
- **Shell** Frac Monitor, Marcellus Shale, wireline deployed DPATS cable for Gas Lift Valve evaluation.
- ConocoPhillips Multiple deployments 2017-2022. VSP, Frac Monitoring, Interference tests, Production Allocation and Gas Lift Valve performance evaluation, VSP
- ExxonMobil Multiple Interference Tests. Multi-well, Multi-Pad Frac Monitoring. Texas, Oklahoma, North Dakota Operations.
- **BP** USA- Production Logging
- **Devon Energy Corporation** Multiple contracts. HF and Injection monitoring.
- **US Department of Energy / Gas Technology Institute** HFTS-2 Joint Industry Partnership (20 Oil and Gas companies) Parts 1, 2, and 3.
- **Birchcliff Energy Canada** Production Logging of 2 gas wells in Alberta, Canada.
- **Rock Cliff Energy USA** Production Logging of 1 oil and gas well. Texas
- Kajima Co. Tokyo new metro line tunnel, Dam(s) deformation
- Japan Railways (East) DAS
- Andra (France) nuclear waste disposal, Bure



Interrogator Unit: NBX-S4100

TGD-technology based distributed acoustic sensing instrument

New TGD-DAS Interrogator – NBX-S4100



Function	Property					
General Function	Optical Fiber Distributed Acoustic Acquisition System、TGD-OFDR					
Laser wavelength	1550 ± 2 nm (Linewidth < 0.1kHz)					
Interrogation Range	1km \sim 120 km					
Finest Spatial Resolution	1.0 m					
Spatial Sampling Interval	0.2 m					
Gauge Length	0.2 m \sim 25 m					
Number of Sampling points	600,000 (maximum)					
Interrogation Rate ^{*2}	500Sps \sim 20KSps (Real time data process)					
Frequency Range	0.1Hz \sim 10kHz					
Chirp Pulse width	2 microseconds					
Spatial Resolution ^{*3}	1m	2m	5m	10m	20m	50m
Distance Dynamic Range ^{*3}	16.0dB	20.0dB	23.5dB	24.0dB	25.5dB	27.5dB
Measurable distance ^{*1}	80km	100km	115km	120km	120km	120km
Output data	Strain rate (με/s)					
Sensitivity ^{*4*5}	10pε/(Hz) ^{0.5}					
File format	HDF5 or SEGY					
Internal Store	4 TB					
Inbuilt loss analysis	TGD-OFDR					
Input-output fiber	Single mode optical fiber					



The NBX-S4100



The FN-DPATS-L4 Cable



TGD DAS in essence	 Optical power is for 200 m long pulse, Spatial resolution is 1.5 m Modulated pulse injected into the fiber linear-frequency modulation (chirp) pulse laser pulse duration 2 μs Time Gated Signal decoded and synthetized any frequency band within the source chirp signal can be extracted from output 	Litedneuco Litedneuco T time
Advantages of the TGD DAS	 High optical power, which is directly related to SNR on receiver side SNR improved considerably over older methods eliminated phase fading (phase singularity) problem easy and efficient signal processing Phase shift information and signal retained seismic applications are very good (proven) changeable spatial resolution (after acquisition) spatial resolution is related to detection and analysis capability long-distance measurements achievable track record of 80 km range measurements (seismic events at seabed) 	signal: sending Total SNR after decoding

TGD-DAS – Robust Source Signal and Sensitive Optical Receiver



- Noise floor Performance of TGD-DAS as benchmark
- Gauge Length of 20 cm enables high amplitude tolerance

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Typical use



- Distributed Acoustic Sensing
 - Sensitivity close to geophones
 - considerably lower per-channel cost
 - If repeated over the same area fiber can be permanently installed
 - completely broadband nature of the DAS signal
 - Repeatable
- Types of use:
 - Active seismic
 - VSP
 - Surface seismic
 - Passive seismic
 - dark fibers
 - Detection of events
 - Stimulation (oil and gas)
 - Leak detection etc.

FBE – typical output – hydraulic fracturing



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Vertical Seismic Profiling (VSP)

Examples of seismic profiling in oil and gas and structural health monitoring

Field deployment – active seismic





TGD DAS VSP Seismic – High Quality VSP Acquisition





Vibroseis Source VSP Acquisition using DAS on Downhole Fiber Down-going P wave first arrival. Consistent.

Down-going mode converted Shear wave, secondary arrival Ghost of down-going P-wave arrival. Probably trapped in the Low Velocity Layer and bedrock. These repeated wave trains are like a down-going multiple noise trains trapped in near surface. Their presence is evidence of the sensitivity and fidelity of this detection system.

The mode converted shear wave velocity measured here is 1180 meters/sec. This matches very well with previous studies conducted by U Calgary at this same site using other surface based seismic methods.

The source was a small 15,000 pound P-wave vibrator, Sweeping For 16 seconds over 10-150 Hz, Linear. 4 individual records were vertically stacked before cross Correlation and then cross correlated with the pilot Sweep to generate this record.

TGD-DAS VSP – Raw Full Wavefield Zero Offset VSP





Walk-away and ZO acquisitions





Walk-away – low SNR and fiber bounding issues (3rd party <u>cable</u>)



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detection 0

The raw data is processed as:

monitoring/leakage

1. raw data

• Tailing dam

- Decoding 2.
- 3. Stacking
- The part highlighted by red line is extracted as the "preprocessed data".

TGD DAS Surface Seismic Body Wave Seismic





- After processing, velocityfrequency imaging is plotted as 2D contour.
- The P wave and S wave are clearly seen in the figure. As example, the line profile for 19 Hz is shown.
- The peaks in the line profile figure corresponds to the proper phase velocity of P wave and S wave, respectively, for 19 Hz.







Micro-seismic

Use of DAS for micro-seismic events detection



- Micro-seismic monitoring
 - Detection of very small-scale earthquakes which occur in the ground
 - Typical hydraulic fracturing, enhanced oil recovery, geothermal operations or mining
- Passive seismicity is also commonly referred to as "induced seismicity."
- Monitoring tries to get answer:
 - 1. When did event occur
 - 2. Where?
 - 3. How big it was?

DAS for quakes and micro-seismic events







Example – detected seismic event – SR = 2 m





STRICTLY CONFIDENTIAL NEUBREX ENERGY SERVICES (US), LLC



- Neubrex offers the cutting-edge technology for acoustic sensing
- NBX-S4000 IU offers:
 - Modulated (chirped) probing pulse for high SNR and Long Distance.
 - Better Spatial Resolution at any given distance of measurement.
 - Lower PSD/Noise Floor for better signal pick-up and analysis.
- NBX-S4000 has been deployed in the field of Oil & Gas, CCSU, and sea-bed cables in US, Canada, and Japan.
- Combined with Neubrex's interrogators for Strain, Temperature, and Pressure, it creates the Distributed Pressure, Acoustic, Temperature, and Strain (DPATS) System.
- And we, OlitGlobals are your local partner close to you.



Thank you.