

Yokogawa Field Instruments


Pressure & Temperature development

&

Process Analyzers

from a engineering perspective

Erik Visser & Loek van Eijck
16-11-2017




KIVI
Engineering Society

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Yokogawa Industrial Automation



FOR THE DIGITAL WORLD


ERP Optimize Control Measure	Production Management Asset Management and Operational Efficiency	Data Acquisition/Recorder	Controller	
	Production Control and Safety Management Data Acquisition and Logic Control	Data Acquisition and Monitoring Paperless Recorder Chart Recorder	Single Loop & Temperature Controller Signal Conditioner Power Monitor	
	Analysis and Quality Control Sensing and Actuation	Analytical	Oxygen Analyzer ZR pH Transmitter FLXA21 Conductivity Transmitter FLXA21 TruePeak Tunable Diode Laser TDL Process Gas Chromatograph GC8000 FT-NIR	
		Pressure	Level	Wireless
		Pressure/Differential Pressure EJA-E/EJX Differential Pressure EJA-E/EJX with seals	Variable Area Rota Meter Coriolis Rota Mass Vortex DY-F Differential Pressure EJA-E/EJX Magn. flow AXF/RXF/AXR	Field Wireless DTSX

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Pressure Transmitters




EJX



EJA-E



Multi-Variable
Pressure Transmitters
(only EJX)



EJX Wireless

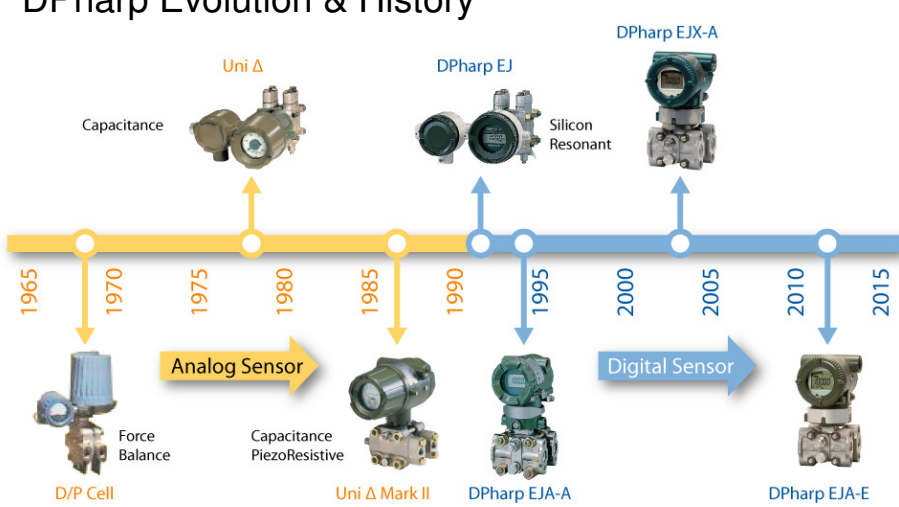
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DPharp Specification

DPharp Evolution & History



Timeline of DPharp Evolution & History:

- 1965: D/P Cell (Force Balance)
- 1970: Uni Δ (Capacitance)
- 1975: Uni Δ Mark II (Capacitance PiezoResistive)
- 1985: DPharp EJ (Silicon Resonant)
- 1990: DPharp EJA-A
- 1995: DPharp EJX-A
- 2000: DPharp EJA-E
- 2015: DPharp EJA-E

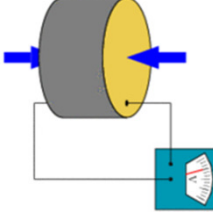
Timeline labels: Analog Sensor (1970-1995), Digital Sensor (1995-2015)

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Piezo-element based transmitters



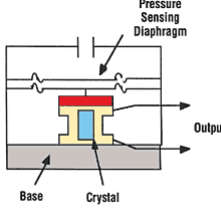
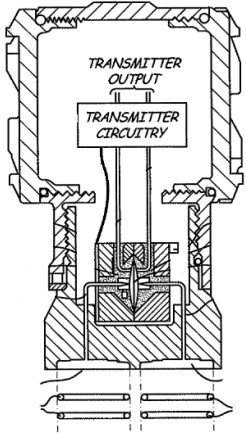
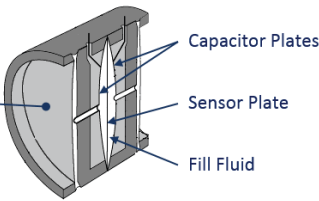


Figure 6. Piezoelectric Pressure Transducer [4]





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Single Crystal Materials

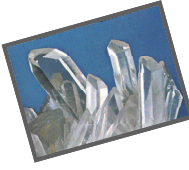
- Single crystal materials have the following generic properties;
 - ◆ Superior elasticity
 - ◆ High long term stability
 - ◆ Hysteresis free
- Therefore sensors based upon these materials are able to offer higher long term precision



Sapphire




Silicon



Quartz



Ruby



Diamond

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The Resonant Sensor

The diagram illustrates the physical structure of a resonant sensor. It features a blue silicon diaphragm with a central channel. An orange arrow labeled 'Pressure' points upwards from the center of the diaphragm. A purple arrow labeled 'Magnetic Field' points downwards towards the channel. Two red arrows labeled 'Tension' and 'Compression' point towards the channel walls. Two red squares labeled 'Electric Terminal' are located on the diaphragm. Three blue arrows labeled '<math><100\mu\text{m}</math>' indicate the dimensions of the channel walls. The title 'The Resonant Sensor' is in a dark blue header.

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Working Principle of the Sensor

The title 'Working Principle of the Sensor' is in a dark blue header. Below the title is a large black rectangular area, which is currently blank, indicating that the content describing the working principle is missing or redacted.

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Dpharp Specifications

Multi-Sensing principal (DP/SP sensing)

Resonator 1 Resonator 2 L
H

Tension $\Delta\epsilon$ $\Delta\epsilon$ **Compression**

L
H

ΔP $\Delta\epsilon \propto \Delta P$

Resonator 1 Resonator 2 L
H

$\Delta\epsilon$ $\Delta\epsilon$ **Compression**

SP **SP**

Frequency (kHz)

150
120
90
60
30

5,000 10,000

f_1
 f_2

Frequency (kHz)

150
120
90
60
30

5,000 10,000

f_1
 f_2

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EJX & EJA

Differential Pressure and Pressure Transmitter

EJX-A

EJA-E

Performance	EJX-A	EJA-E
ACCURACY		
+/- 0.025%	●	
+/- 0.040%	●	●
+/- 0.055%		●
+/- 0.065%		
STABILITY		
+/- 0.1% of URL for 10 years	●	
+/- 0.1% of URL for 7 years		●
+/- 0.1% of URL for 5 years		
TURN DOWN		
200 : 1	●	
100 : 1		●

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DPharp App

360° Viewer

Calibration Frequency

Videos

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Distributed Temperature Sensor

DTSX™
BY YOKOGAWA ◆

E. Visser


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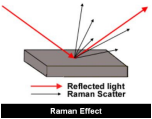
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Introduction DTS Technology

- The fiber optic Distributed Temperature Sensing (DTS) method using the **Raman-effect** has been developed at Southampton University in England, UK in the early 80's.
- The DTS method is based on **Optical Time-Domain Reflectometer (OTDR)** technology and uses a technique derived from telecommunication cable testing.
- The fiber optic-based DTS method measures temperature using **optical fiber** instead of thermocouples or thermistors
- DTS systems represent a **cost-effective method** for obtaining thousands of accurate, high-resolution temperature measurements.
- DTS technology offers a safe and **non-intrusive measurement** with has the capability to pinpoint the **precise location** of any warm or cold spot instantly.





Raman Effect



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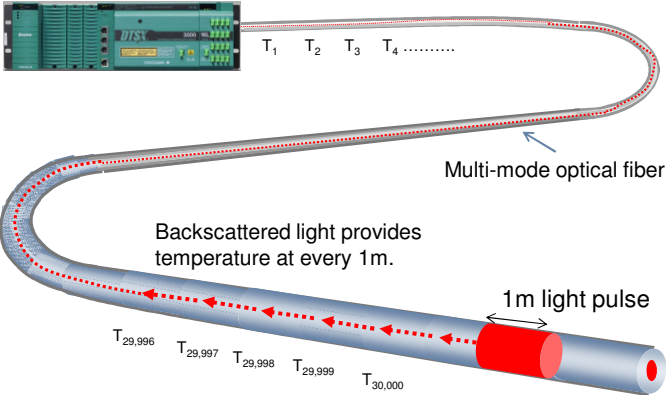
Distributed Temperature Sensor (DTS)

Optical Fiber is “Temperature Sensor”

Safe – No electronics – explosion proof & non-inductive
Distributed Measurement: Every 1m average temperature measurement of **30km fiber = 30,000 sensors!**

DTS Instrument
(interrogator)






Multi-mode optical fiber

Backscattered light provides temperature at every 1m.

1m light pulse

Specialty Optical Fiber Cable (example)



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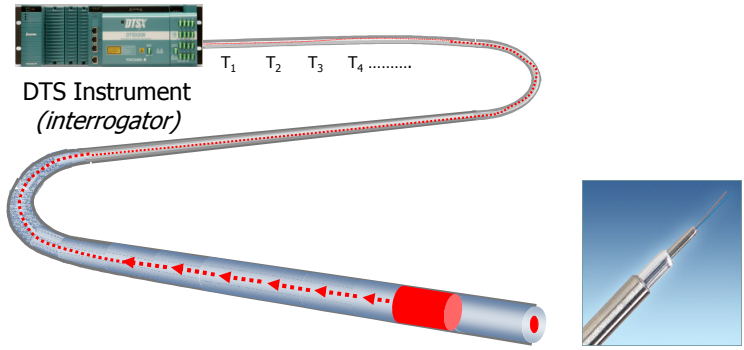
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Distributed Temperature Sensor (DTS)

Principle

Measurement

- Distributed Measurement - 1 m spatial resolution
- Measurement of 50 km
 - ◆ Optical fiber = 50,000 sensors!
- Backscattered light provides temperature at every 1 m
- Standard multi-mode optical fiber



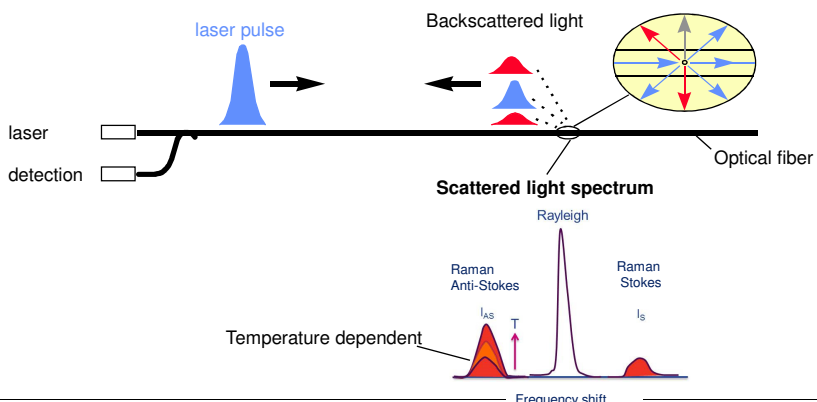
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Distributed Temperature Sensor (DTS)

Principle

Spectrum

- Light is backscattered from natural anomalies within the fiber
- This happens at all points within the fiber
- Range gating allows specific sections along the fiber's length to be examined



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DTS Measurement Principle

Principle

Spectrum

DTS PRINCIPLES

The diagram illustrates the DTS measurement principle. It starts with a Pulsed Laser connected to a Directional Coupler. The Directional Coupler splits the light into two paths: one leading to the DTS Unit and another leading to an Optical Receiver. The DTS Unit contains a Signal Processing block. The Optical Receiver is connected to an Optical Fiber. The Optical Fiber is shown with a legend: a yellow starburst represents Raman Backscattering and a red square represents a Laser Pulse. The Signal Processing block outputs a 'Spectrum of Backscattered' graph, which plots Return Signal Intensity against Return Signal Wavelength. This graph shows three peaks: Incident Light, Anti-Stokes Signal (Strongly Temperature Dependent), and Stokes Signal (Weakly Temperature Dependent). The Anti-Stokes signal is used to determine the temperature profile, which is shown in a 'TEMPERATURE vs DISTANCE' graph. The graph shows a fluctuating temperature profile over a distance. © annotation by SensorTran

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Main Specification

Item		Specification	
		DTSX200(Mid-Range)	DTSX3000(Long Range)
Performance	Distance range	6km	10, 16, 20, 30, 50Km
	Temperature resolution (1 Sigma)	0.2 °C (3 km , 10 min) 0.6 °C (3 km , 1 min) 1.1 °C (3 km , 10 sec)	0.03°C (10Km , 10min) 0.06°C (16Km , 10min) 0.20°C (30Km , 10min)
	Spatial resolution	1m	1 ~2m
	Optical switch	2ch, 4ch, 16ch (Option)	
Measurement temperature range		-200 ~ +500 °C (depends on the optical sensor cable specification)	
Operation ambient	Ambient temperature	-40 ~ + 65°C	
	Ambient humidity	20 – 80% RH (no condensation)	
Network interface	LAN	Modbus/TCP HTTP(S) PUT/GET (Secured Protocols) SFTP/SCP (Secured Protocols)	
Power consumption		10W (Operating) 2W (Power saving)	16W (Operating) 2.W (Power saving)

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Temperature Resolution

Resolution

Distance

Temp. (°C)

Distance (km)

Longer the
Fiber Length

↓

Less accurate
temperature
measurement

Temp. res.

Measurement. time

10-sec
30-sec
60-sec
180-sec
600-sec

Distance

Longer the
Measurement time

↓

More accurate temperature
measurement

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DTSX Applications

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Applications: Pipeline Leak Detection

- Quick detection of small leakage events and monitoring of the pipeline temperature profile.
- Pipelines such as LNG, LPG, ammonia, ethylene create cold zones which can be easily detected when leaks occur.

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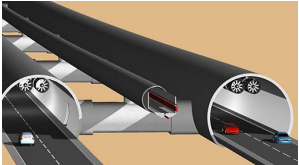

LNG Tank lead detection

DTSX can identify small leakage

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Applications: Downstream and Others

- Refinery and Plants
 - ◆ Vessel "Hot Spot"
 - ◆ Tank & Pipeline Leak Detection
- Fire Detection
 - ◆ Industrial Facilities
 - ◆ Tunnels
 - ◆ Structures & Buildings



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Process Analyzers

from a engineering perspective

Loek van Eijck
Analyzer Center Europe

November 2017

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Yokogawa Analytical History

As of January 2017

YOKOGAWA founded as electric meter research institute

1915 Founded by Dr. Tamisuke Yokogawa

1917 First electronic meters in Japan

1957 First 4 W Tx in Japan

1959 First GC in Japan

1970 First Zirconia in Japan

1975 World's 1st PTB & BASEFA certified 2W Transmitter

1977 World's 1st Online Sensor diagnostics

1985 Incorporated as Measurement Inc.

1994 World's 1st 2. Generation Touch screen liquid analysers

1994 World's 1st Touch screen liquid analysers

1997 Yokogawa Electric Corporation acquired 51% of MI

1998 Established Singapore Operation, MS Pte Ltd

2000 Yokogawa Electric Corporation 100% of MI

2005 World's 1st Touch screen liquid analysers

2011 3. Generation Touch screen liquid analysers

2015 World's 1st TDLS with SiL 2, in built reference cell

2016 Joined Yokogawa

United Control Houston founded as independent system integration company

1967 Founded as independent system integration company

1985 Incorporated as Measurement Inc.

1997 Yokogawa Electric Corporation acquired 51% of MI

1998 Established Singapore Operation, MS Pte Ltd

2000 Yokogawa Electric Corporation 100% of MI

2008 M&A of Analytical Specialties

Analytical Specialties
TDLS manufacturer

Reflux sampler manufacturer

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Process Analyzers Solutions

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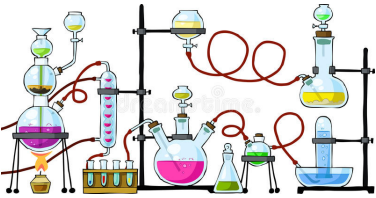
Analyzer Solutions

■ Why do we need process analyzers?

Each plant has a laboratory for measuring chemical components and/or physical properties

So, WHY?

- *Fast results*
- *No human interference*
- *No influence on sample composition*




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Analyzer solutions contribute to the plant performance

■ Process Analyzers contribute to:

- ◆ **Product Quality**
- ◆ **Throughput / Yields Optimization**
 - > Debottlenecking of the plant unit
 - > Increase yield of product (control of chemical reaction)
- ◆ **Plant Safety**
 - > Prevention of explosions
 - > Health safety aspects



ECONOMIC
BENEFITS



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System Integration solution

80 % of Analyzer System problems are caused by a wrong design of the Sample Conditioning System

Engineering Important aspect!

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Engineering

- To implement a process analyzer require engineering
 - Site Survey/Feasibility study
 - Front End Engineering design
 - Project management & Detailed engineering
 - In-house fabrication and assembly
 - In-house Testing & FAT (acceptance test)
 - Start-up/Commissioning
 - Maintenance support

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Overview

■ Process Analyzer System Flowchart

The flowchart illustrates the integration of a process analyzer into a plant's control system. It starts with a photograph of an industrial process plant. A red arrow indicates the sample flow from the plant through three stages: ① Sample Preconditioning System, ② Sample Conditioning System, and ③ Analyzer. These three stages are contained within a 'Shelter or Cabinet'. A green double-headed arrow connects the Analyzer stage to the 'DCS' (Distributed Control System). A dashed green line labeled 'Process Plant Control' connects the plant to the DCS.

① Sample Preconditioning System
 ② Sample Conditioning System
 ③ Analyzer

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Deliverables Yokogawa Analyzer Solutions *examples*

- Analyzer Cabinet's/Houses
- Samples Systems
- Analyzer panels

The images showcase a variety of Yokogawa analyzer solutions in industrial settings. The top row shows a complex piping system with multiple analyzers, a close-up of a sample system with numerous valves and tubes, and a large white industrial cabinet. The bottom row features a long row of white cabinets in a control room, a perspective view of a long aisle of cabinets, and a detailed view of an analyzer panel with multiple gauges and sensors.

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Process Gas Chromatograph

example

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Process Gas Chromatograph (GC)

- **Process GC**
 - ◆ Most versatile multi-component analyzer
 - ◆ **GC application** engineer start with process datasheet
 - GC chemist develop separation concept followed by GC hardware configuration
 - ◆ **System Integration** engineer
 - Detail engineering how to handle the process stream to provide a representative sample.

From process to analyzer

GC8000



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Engineering details

INSTRUMENT DATA SUMMARY BY ANALYZERS	
TAG NUMBER	AT-001
PDF NUMBER	1200-PS-PFD-020101
PLAD NUMBER	1200-PS-PFD-00101
LINE NUMBER	P12010101
ANALYZER SERVICE	
ANALYZER STREAM No.	
PDF STREAM NUMBER	1201
OPERATING PRESSURE	4.00
OPERATING TEMPERATURE	40.00
PHASE	V
VAPOR MOL WEIGHT	19.83
VAPOR COMPRESSIBILITY FACTOR (Z)	0.991
PHYSICAL PROPERTY ANALYZER	
MEASURED PROPERTY	PROPANE
NORMAL OPER. VALUE	BTU/HR
RANGE	CS 200
NOTES:	
1. Analyzer Type : Gas Chromatograph	
2. Design Pressure : 10.0 Bar(Ga)	
3. Design Max.Min. Temperature : 120/5 deg	
4. Toxic service	
5. Response time : 10 minutes per stream	
6. Repeatability +/- 0.5% over full scale	

Column System

Separation system

Oven Temperature: 75 Deg. C

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Engineering result

Sample Conditioning System

Process Gas Chromatograph

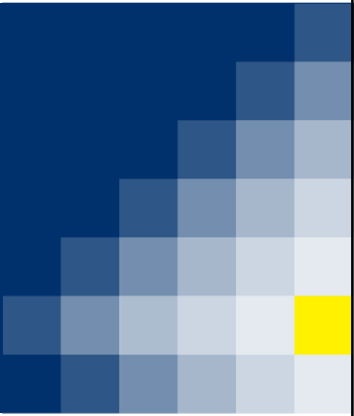
GC columns system

Result: Chromatogram

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Questions?

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