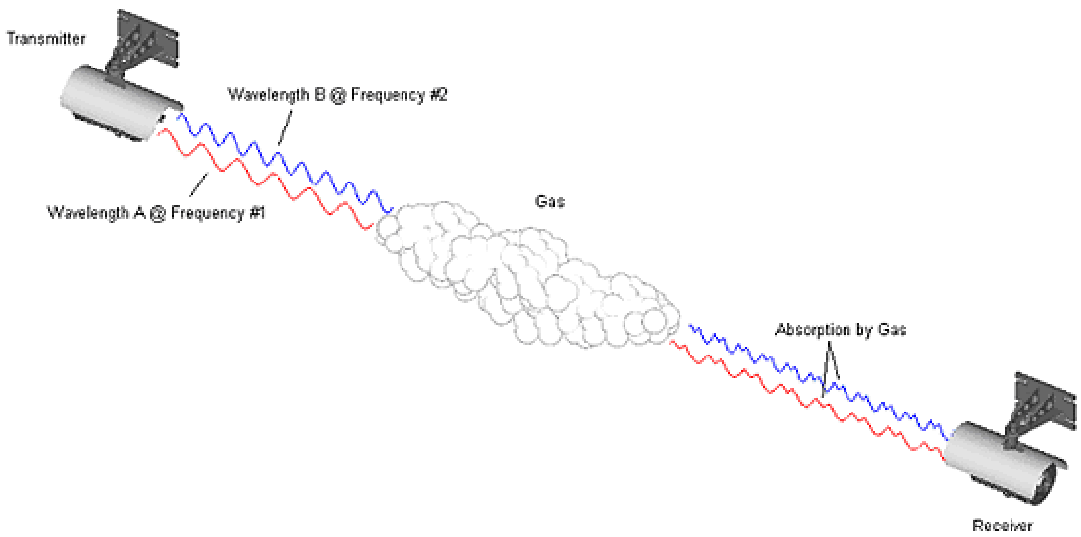
Senscient
Fulfilling the promise of Open Path Gas Detection (OPGD)

Technology



History

Open Path Gas Detectors (OPGD) utilizing NDIR detection techniques have been in use since the late 1980's and are widely accepted for many Oil & Gas, Petrochemical and other industry's combustible gas detection applications. OPGD systems are currently used to monitor hydrocarbon gas leaks at offshore and onshore oil and gas production facilities, refineries, petrochemical plants, gas transmission stations and many other industrial facilities.

The earliest NDIR OPGD systems were plagued with environmental interferences and failed to provide consistent performance when exposed to direct sunlight or weather conditions such as rain, snow and fog. In order to cope with these environmental challenges, designers of OPGDs pushed NDIR technology to its limits, but this has left little room for further improvement. Consequently, there are many demanding flammable gas detection requirements which cannot be adequately met using NDIR-based equipment. HVAC ducts and turbine acoustic enclosures are examples of applications where NDIR-based systems cannot meet the needs of many customers.

In order to address the most demanding flammable gas detection requirements and to provide the first reliable open path toxic gas detector, Senscient developed Enhanced Laser Diode Spectroscopy (ELDS™).

Enhanced Laser Diode Spectroscopy (ELDS)

Enhanced Laser Diode Spectroscopy is a revolutionary gas detection technology, specifically developed for safety related applications in industry. ELDS provides the following unique benefits and advantages:

- ELDS based OPGD systems provide reliable, sensitive detection of both flammable and toxic gases at low ppm concentrations. Toxic gases of primary interest include hydrogen sulfide, hydrogen fluoride and ammonia.
- ELDS-based OPGD systems offer three orders of magnitude in increased sensitivity for hydrocarbons, greatly increasing the probability of detecting a flammable gas leak before it reaches catastrophic proportions. Current NDIR methodology fails to provide warnings early enough, or reliably enough to facilitate any significant remedial action.
- ELDS based OPGD units can be produced for combinations of toxic and / or flammable gas hazards, significantly reducing the cost for a comprehensive gas detection system.
- Unique **Simu-Gas™** feature provides the long sought-after ability to accomplish remote, on command, electronic functional testing of open path gas detectors either locally or from the control room.

ELDS: Table of Detectable Gases

Hydrogen sulphide	H_2S
Hydrogen fluoride	HF
Hydrogen chloride	HCl
Hydrogen bromide	HBr
Hydrogen iodide	HI
Hydrogen cyanide	HCN
Ammonia	NH_3
Carbon monoxide	CO
Carbon dioxide	CO_2
Oxygen	O_2
Methane	CH_4
Ethane	C_2H_6
Propane	C_3H_8
Butane	C_4H_{10}
Ethylene	C_2H_4
Propylene	C_3H_6
Acetylene	C_2H_2
Methanol	CH_3OH
VCM	C_2H_3Cl
EDC	$C_2H_4Cl_2$

Theory of Operation Concepts:

Using a separate transmitter / receiver configuration, ELDS systems detect and measure gas concentrations at specific target gas absorption wavelengths over distances of up to 200 meters. The detector measures absorbance changes along the line-of-sight path when a combustible or toxic gas passes through the beam. **Enhanced Laser Diode Spectroscopy (ELDS)** utilizes highly reliable, solid-state laser diode sources similar to those used in demanding telecommunications applications. Innovative signal processing methods significantly increase sensitivity, enabling reliable detection down to fractions of a % LEL meter of combustible gases, and low ppm meter levels of toxic gases. ELDS addresses problems experienced by traditional laser diode systems including laser Relative Intensity Noise (RIN), absorption by atmospheric gases, and coherence / fringe effects. ELDS uses a combination of techniques which significantly enhance the ability of an OPGD to detect small fractional absorbances with an extremely low false alarm rate.

ELDS techniques allow our customers to finally meet stringent regulatory and safety integrity requirements with a false-alarm free system for low level combustible and toxic gas detection.

Multiple Modulation Frequencies:

To successfully address system noise and the associated unacceptable false alarm rates, the ELDS technique employs Multiple Modulation Frequencies. The laser diode is driven by a current as shown in Figure 1, comprising two components, a bias component and a sinusoidal wavelength modulation component. The bias component is chosen to operate the laser diode at a wavelength close to a chosen optical absorption line of the target gas. The sinusoidal component alternates between two, non-harmonically related electrical frequencies f and f'. At each of the chosen frequencies, the laser's wavelength is alternately scanned across the chosen absorption line for a designated time interval.

When there is no gas present in the measurement path, the combined Fourier transform of the detector signal will look like Figure 2, with just two frequency components f and f'.

When there is a substantial quantity of target gas in the monitored space, the combined Fourier transform of the detector signal will look like Figure 3, with sets of harmonics of both f and f'. The probability of both measurements simultaneously suffering noise induced deviations above the alarm threshold is extremely small, lower than the targeted 1 in 100 years false alarm rate probability.

The benefits of modulation and measurement at multiple, non-harmonically related electrical frequencies are not limited to reducing the impact of inherent system noise. The use of modulation at a number of non-harmonically related frequencies also reduces the likelihood that electromagnetic interference and/or thermal noise will affect all measurement frequencies simultaneously, again enabling false alarm rates to be significantly reduced.

Harmonic Fingerprints:

Although conventional Laser Diode Spectroscopy (LDS) methods of measuring gases have been in use for several years in process control and environmental monitoring applications, such systems have not been popular in safety related applications due to their high false alarm rates when detecting low levels of hazardous gases. Conventional LDS systems suffer from the combined effects of system noise, absorption by atmospheric gases and coherent interference effects, all of which can produce spurious readings and false alarms.

ELDS overcomes the false alarm problems experienced by conventional LDS systems by the use of **Harmonic Fingerprints™**. Using a small retained sample of target gas inside the transmitter, the temperature and wavelength modulation currents applied to the transmitter's laser diodes are actively controlled to lock the lasers such that absorption by target gas produces specific Harmonic Fingerprints. The relative amplitudes and phases of the harmonic components in a Harmonic Fingerprint are so specific that only absorption by target gas produces a signal with the desired Harmonic Fingerprint. Noise, absorption by atmospheric gases and coherent interference effects never produce signals with the Harmonic Fingerprint, enabling an ELDS-based gas detector to effectively eliminate false alarms from these causes.

Multiple Measurement Wavelengths:

It is widely understood that measuring gases with a single wavelength can be limiting to the sensitivity and accuracy of the measurement. Multiple wavelength measurement and detection, employed by scanning spectroscopy systems, has long been the technique of choice for analyzers providing low level, selective analyses of gas concentrations in the lab and on the process floor. But for ambient gas detection systems, multiple-wavelength scanning has been too complicated and too expensive to employ in the majority of applications. The Vertical Cavity Surface Emitting Lasers (VCSELs) employed in Senscient's ELDS-based gas detectors provide economic scanning of wavelength ranges of 2-3nm, enabling multiple wavelength or multiple species measurements.

Multiple Laser Diodes:

Even though it is not possible to completely eliminate coherence / fringe effects from a laser diode system (especially one operating along an open measurement path) it is possible to reduce the rate of false alarms arising from such effects by using a system configuration as shown in Figure 5. The ELDS system shown in Figure 5 contains two laser diodes, operating at two different wavelengths corresponding to two different absorption lines of one or more target gases. The outputs from the lasers are collimated by a common optical element,

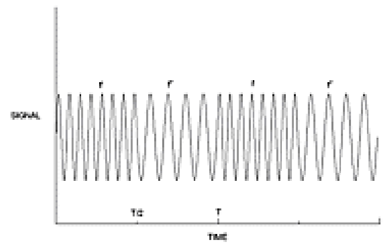


FIG. 1 Laser Diode Drive Waveform Including Two, Non-Harmonically Related, Wavelength Modulation Frequencies

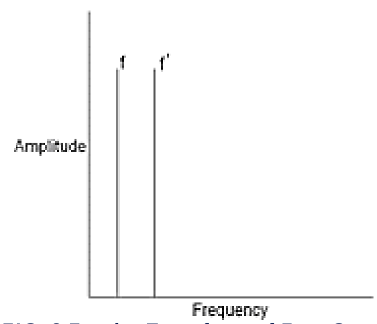


FIG. 2 Fourier Transform of Zero Gas Signal For Interval T

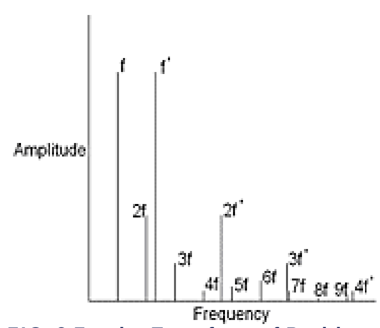


FIG. 3 Fourier Transform of Positive Gas Signal For Interval T

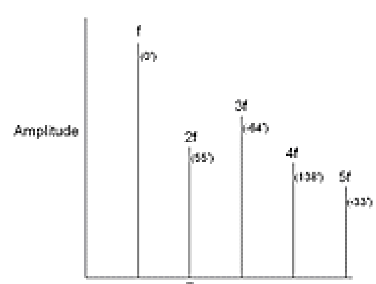


FIG. 4 Example of a Harmonic Fingerprint Generated by Controlled Scanning of a H2S Absorption Line

aligned such that optical radiation from both laser diodes reaches the receiver after passing through the monitored path. The optical radiation received from both laser diodes is concentrated onto a detector, at which point the optical signals are combined into a single electrical signal.

The use of multiple laser diodes and multiple measurement wavelengths is an effective way of addressing problems with coherent interference / fringe effects, a common problem experienced by conventional LDS systems. Two and even three VCSEL laser diodes can easily be mounted on a common temperature stabilized mount, sharing all of the associated optics and detectors; whilst keeping system costs reasonable.

The electrical signal from at the detector contains two sets of independent frequency components proportional to the amount of target gas present in the measurement path. These effectively independent measurements of the quantity of target gas in the monitored space can then be compared and used to confidently determine the quantity of target gas present in the monitored space, if any.

at 1589.97nm

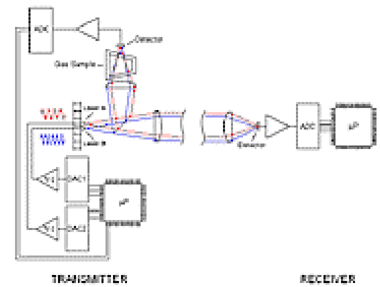


FIG. 5 Dual Laser ELDS Based Gas Detection System

Multi-Gas Capability:

The use of two lasers, scanning different wavelengths at different electrical frequencies makes it possible to treat each measurement as being completely independent of the other. Consequently, ELDS provides the opportunity to monitor two or more different target gases simultaneously in the same transmitter/receiver system (see Figure 6). Combinations of gases that are likely to be of interest include methane + hydrogen sulfide (solution gas), butadiene + hydrogen fluoride (alkylation) and methane + methanol (methanol injection).

Increased system reliability, virtually false-alarm free low level gas detection, and even simultaneous multiple gas detection capability is now possible.

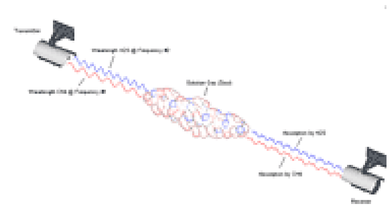


Fig. 6 ELDS system showing the detection of two different target gases simultaneously using the same receiver/transmitter configuration.

Simu-Gas:

Senscient introduces the concept of **Simu-Gas™** for the simplest and most reliable gas detector functionality test available.

In an ELDS system with Simu-Gas as shown in Figure 7, the transmitter's microprocessor has direct control of the synthesis of the laser diode drive waveforms, and access to the Harmonic Fingerprints being produced by absorption of laser diode radiation by the retained sample of target gases.

Upon receiving a command instruction from an operator or control system, the transmitter's microprocessor adds Harmonic Fingerprint components to the laser diode drive waveforms to simulate the presence of a given quantity of target gas in the monitored space. The optical radiation leaving the transmitter then faithfully simulates the presence of target gas in the monitored path.

When the receiver processes the signal that it is receiving from the transmitter, it sees the Harmonic Fingerprint components and calculates and outputs the corresponding quantity of target gas. By simply comparing the gas reading output by the receiver to the quantity of target gas that the transmitter was instructed to simulate, it is possible to verify the correct operation of the gas detector.

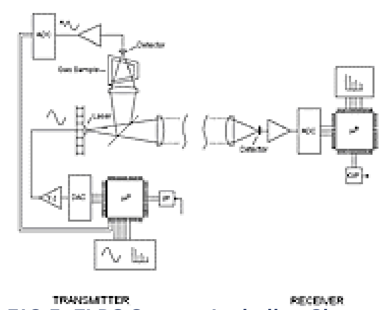


FIG 7. ELDS System Including Simu-Gas

Compared to the conventional techniques currently used to test gas detectors, Simu-Gas testing has the following advantages:

- Functional testing can be performed remotely, without operators needing to gain access to difficult-to-reach gas detectors. No more scaffolding or abseiling!
- Gas detectors can be functionally tested much more frequently, providing greater safety integrity. Simu-Gas enables SIL 2 or SIL 3 gas detection systems to be easily realised.
- There is no need for operators to carry cylinders of hazardous gases around facilities in order to test gas detectors.
- The results of detector functionality testing can be gathered and logged automatically.
- The operation and maintenance costs for a gas detection system are greatly reduced.

Cost of Ownership reduces to almost zero with this innovative technique that permits gas detector functionality to be confirmed on command, locally or remotely under any condition.

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Senscient introduces affordable, reliable, line-of-sight flammable and toxic gas detection utilizing revolutionary Enhanced Laser Diode Spectroscopy (ELDS™)

"... Simu-Gas™ feature insures optimum safety system integrity..."

"...multi-gas capability saves project capital costs..."

"... virtually no cost-of-ownership..."