BIO 2000 DUCT

Features

- **Bio-sensor-conductor type**
- **Measurement range 0-2000 ppm VOC/CO_2 (on request 0-4000 ppm)**
- **Accuracy ± 150 ppm**
- **Analog output signal (0)4-20 mA or (0)2-10 Vdc (selectable)**
- **Serial interface Modbus RS-485**
- **Power supply 24 Vac/dc**
- **IP65 protected**
- **Internal automatic self-diagnostics with auto adjustment**
- **High accuracy, selectivity and reliability**
- **Automatic drift and temperature compensation**
- **Good resistance to poisoning**
- **Life expectancy > 10 years**
- **Maintenance interval > 5 years**

Detectable gases

- Cigarette smoke
- Automobile exhaust
- Breath air
- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Solvent fumes
- Alcohol fumes
- Acetone
- Acrylonitrile
- Ammonia
- Benzene
- Chlorine
- Dimethyl amine
- Ethane
- Ethylene
- Ethylene oxide
- Formaldehyde
- Hydrogen
- Hydrogen sulfide
- Isobutane
- Methane
- Methanol
- Methyl chloride
- Methylene chloride
- Methy ether
- Methyl acetate
- Methyl ethyl ketone
- n-Hexane 2
- n-Petane
- Propane
- R-11
- R-12
- R-502
- R-123
- Sulfur dioxide
- Vinyl chloride

Applications

- Offices
- Hotels
- Meeting rooms
- Convention centres
- Schools
- Airports
- Apartments
- Stores,
- Restaurants etc.

Ordering

Type no.	Description
BIO 2000 DUCT	Duct air quality VOC/CO_2 sensor 0-2000 ppm, (0)4-20 mA or (0)2-10 Vdc Modbus RS-485.

Description

The duct air quality VOC/CO_2 sensor BIO 2000 DUCT is a simple, low-cost and low maintenance VOC (Volatile Organic Compounds) and CO_2 (Carbon Dioxide) sensor based on modern semiconductor technology.

The sensor detects the VOC/CO_2 content in air and emits a proportional, linear, analog (0)0-10 Vdc or (0)4-20 mA and digital ModBus RS-485 signal.

The different housing versions make the duct air quality VOC/CO_2 sensor BIO 2000 DUCT available to almost any application or environment.

In case of restart/voltage breakdown a signal of 80% is output for 20 minutes for maximum ventilation. During this time the duct air quality sensor BIO 2000 DUCT adopts the current VOC/CO_2 value as zero point.

In case of improvement of the air quality an automatic correction of the zero-point is performed.

The normal CO2 values are not causing any problems in closed areas but different substances like VOC can be responsible for symptoms like eye irritations, headaches, feebleness, dizziness, as well as for diseases and overexertion like the sick building syndrome.

Beyond measurement of CO2 concentration the duct air quality VOC/CO_2 sensor BIO 2000 DUCT detects the air quality similar to human sensation. That's why VOC/CO_2 measurement is the perfect method to define air quality.

The duct air quality VOC/CO_2 sensor BIO 2000 DUCT is suitable for nearly all application ranges.

Gas inlet	Via a sampling pipe/ connection tube
Flow speed	Min. 5000 m/h, Max. 20,000 m/h
Duct diameter (ca.)	Min. 0.1 m, max. 1.0 m
Length of sampling pipe	250 mm, adaptable to the duct diameter by cutting to lengths: 192, 133 or 77 mm
Tube length	2 x 1000 mm
Mounting	Arrow at the sampling set in flow direction. Always mount in the middle of the duct. Keep a minimum distance of 1000 mm to duct bends etc.

Technical data

Electrical

Power supply	24 Vac/Vdc ±20%, 50 Hz (half-wave rectifier input)
Power consumption	< 1 Watt (average)

Sensor data (Sensor data only valid for circulating air)

Gas type*	see page 1.
Sensor technic	Bio-semi-conductor
Measuring range	0 -2000 ppm VOC/CO_2 (on request 0-4000 ppm).
Accuracy	± 150 ppm
Repeatability	± 5 % of reading
Response time	t90 < 60 s Warm-up time 20 min.
Sensor life expectancy	>10 years / normal ambient conditions
Maintenance interval	> 5 years

Output Signal

OUT1 linear	4-20 mA / 0 -10 Vdc / 0 -2000 ppm VOC/CO_2
D/A resolution	10 Bit, 10 mV
Electrical parameters	R_{OUT} < 100 Ohm, R_{LOAD} > 5 kOhm

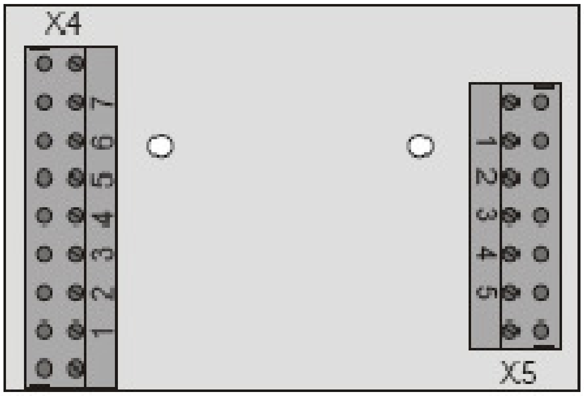
Environmental Conditions

Humidity	5 to 95% RH non-condensing
Working temperature	0°C to +50°C
Storage temperature	-10 °C to + 50 °C

Enclosure

Enclosure material plastic type A	Polycarbonate Flammability UL 94 V2
Colour	RAL 7032 (light gray)
Dimension (W x H x D)	94 x 130 x 57 mm
Weight	0.15 kg
Protection class	IP65
Cable inlet	Standard 1 x M 20
Connection	Screw-type terminals min. 0.25 max. 2.5 mm2
Guideline	EMC Directives 2004/108/EC EN 61010-1:2010, ANSI/UL 61010-1 CAN/CSA-C22.2 No. 61010-1 CE
Warranty	1 year / material

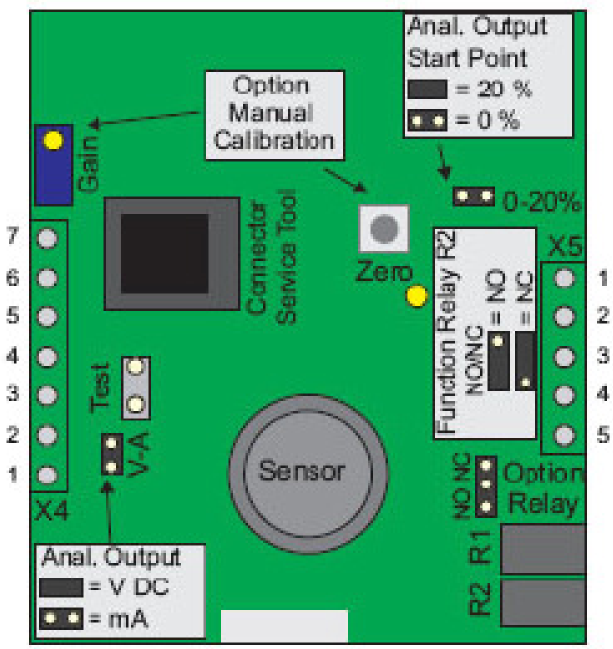
Terminal Block



Wiring

7	Bus_B
6	Bus_A
5	4-20 mA input
4	0-10 Vdc or 4-20 mA output
3	24 Vdc out
2	Ground
1	24 Vac/dc

PCB



Output 0-10 Vdc or 4-20 mA is jumper selectable on pcb.

Power supply can be 24 Vac or 24 Vdc
for both 0-10 Vdc output and 4-20 mA output.

4-20 mA output is 2-wire (loop) connection on terminals 1 and 4.

0-10 Vdc is 3-wire connection on terminals 1, 2 and 4.

Relay outputs are options.

Wire connection on screw terminal min 0.25 mm2 and max 2.5 mm2

Wire distance:
500m for 4-20 mA output and 200 m for 0-10 Vdc output.

Intelligent air quality

Adults consume two to three liters of liquids and one to two kilograms of food per day. While hygiene and safety of edibles receive great attention, air quality gets very little even though on average we inhale
15 kg of air per day — **80% of which indoors.**

From the classroom to the cubicle, the benefits of maintaining good indoor air quality extend beyond protecting the occupants' health.

Students in schools with healthy air are more proficient at retaining information and teachers have fewer sick days.

For employers, studies show that improving indoor air quality directly correlates with higher productivity and a more satisfied workforce.

Moreover, the advent of "green buildings" and emission-dependent energy taxes has created awareness for both indoor air quality and ventilation energy costs.

Consequently, in modern or reconstructed buildings, the alternatives of either having minimal ventilation with poor air quality on the one hand or permanent ventilation with high ventilation energy costs on the other are impractical.

A balance between the two extremes exists in "Demand Controlled Ventilation" or DCV.

This paper is focused on air quality sensors for DCV. It describes typical indoor air contaminants, their sources, and their impact on human health.

Moreover, it confronts current indoor air quality standards with modern ventilation demands and compares today's commercially available air quality sensor technologies accordingly.

Finally, suggestions for improvement of typical ventilation scenarios by using BIO intelligent air quality solutions are provided.

Anatomy of Indoor Air

Clean air is comprised of 21% oxygen, 78% nitrogen and 1% argon.

However, indoor environments are different where other noble gases, carbon monoxide (CO), carbon dioxide (CO2) and volatile organic compounds (VOCs), also known as mixed gas, exist with different prominence.

When it comes to the impact on health the latter two are the most important ones: CO2 for its HVAC (Heat, Ventilation, and Air Conditioning) industry awareness, and VOCs for their criticality.

…beyond CO2

The Role and Impact of VOCs in Indoor Air

There are estimated to be 5,000 to 10,000 different VOCs, which are two to five times more likely to be found indoors than outdoors. Indoor VOCs are hydrocarbons that originate from two primary sources: bio-effluents, that include odors from human respiration, transpiration and metabolism; and vapors generated from building materials and furnishings.

VOCs cause eye irritations, headache, drowsiness or dizziness, and contribute to a condition known as "sick building syndrome" or SBS, whereby adequate ventilation must be provided.

Aside from industrial conditions and comfort aspects such as temperature control,
VOCs are the most critical reason to ventilate.

Some typical indoor contaminants and their sources are shown in Table 1.
Clearly, humans represent the greatest source of VOCs, directly and indirectly; far beyond building materials, furniture and office equipment, and thereby dominate the demand for ventilation.

Indoor Air		Typical Substances		Cure
Contamination Source	Emission Source	VOCs	Others	
• Human Being	• Breath	Acetone, Ethanol, Isoprene		demand controlled ventilation
			CO_2	
			Humidity	
	• Skin Respiration & Transpiration	Nonanal, Decanal, α-Pinene		
			Humidity	
	• Flatus	Methane, Hydrogen		
	• Cosmetics	Limonene, Eucalyptol		
	• Household Supplies	Alcohols, Esters, Limonene		
	• Combustion (Engines, Appliances, Tobacco Smoke)	Unburnt Hydrocarbons		
			CO	
			CO_2	
			Humidity	
• Building Material • Furniture • Office Equipment • Consumer Products	• Paints, Adhesives, Solvents, Carpets	Formaldehyde, Alkanes, Alcohols, Aldehydes, Ketones, Siloxanes		permanent 5-10% ventilation
	• PVC	Toluene, Xylene, Decane		
	• Printers, Copiers, Computers	Benzene, Styrene, Phenole		

Table 1 – Typical Indoor Air Contaminants (VOCs and others)

The Role and Impact of CO2 in Indoor Air

Although CO2 is listed twice in Table 1 and plays a major role in modern ventilation control, it has no permanent effect on humans, especially in small doses.

Exposures on submarines and the International Space Station confirm that even heavy CO2 concentrations of 1% (10,000ppm) show no irreversible impact on occupant well-being.

Due to the lack of suitable VOC sensing devices, CO2 has served historically as an adequate air quality indicator.

Moreover, **since the amount of CO2 is proportional to the amount of VOCs produced by human respiration and transpiration (Metabolic Rule)** CO2 levels reflect the total amount of VOCs (TVOCs) as illustrated in Diagram 1.

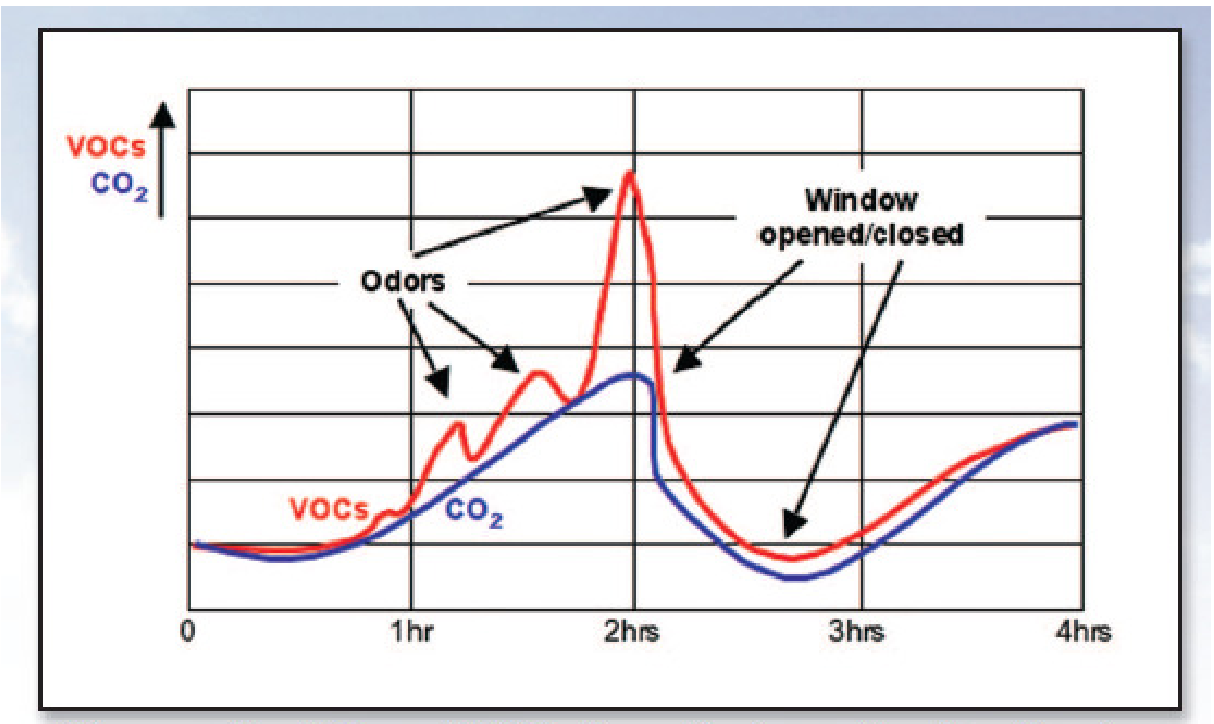


Diagram 1 – CO_2 and VOCs from Business Meeting Session

The Volatility of Volatile Organic Compounds

Diagram 1 illustrates more than just the correlation between VOCs and CO2.
Importantly, the diagram also demonstrates that VOCs are much more volatile, or sudden in their occurrence.

An increase of human bio-effluents or the intermittent use of odorous materials such as cleaning supplies, perfumes or cigarette smoke is not uncommon.

Diagram 1 shows spikes of these events; thus, relying exclusively on CO2 as a ventilation reference will lead to unsatisfactory results.

Ventilation should react on demand toward all contamination sources, not only CO2.
This points out the weakness of CO2 - based DCV. Detecting a broader range of contaminants optimizes ventilation energy savings and minimizes the impact on human occupants.

CO_2 [ppm]	Air Quality
2100	BAD Heavily contaminated indoor air Ventilation required
2000	
1900	
1800	
1700	
1600	
1500	MEDIOCRE Contaminated indoor air Ventilation recommended
1400	
1300	
1200	
1100	
1000	FAIR
900	
800	GOOD
700	
600	EXCELLENT
500	
400	

Table 2 – Classification of Indoor Air Quality

Indoor Air Quality References From Past to Present

Historically, CO2 has been the detection gas of choice since it is a reasonable reference and its detection is fairly easy.

Mixed gas or VOC detectors suffered early criticism due to long-term stability problems and the inability to calibrate output units.

Further, without suitable threshold values, HVAC planners using VOC detectors could not easily set ventilation rates and VOC sensor drift made the entire ventilation system functionally unpredictable. Although the motivation to measure the root cause for contaminated air was appropriate, the implementation was not successful.

BIO Sensor Approach — Close to Human Perception

Taking into account the lack of VOC standards, BIO sensors iAQ, intelligent Air Quality, sensor takes advantage of its Reversed Metabolic Rule technology, RMR.

RMR technology calibrates measured VOC concentrations to CO2 - equivalent ppm-values, thereby achieving full compatibility to CO2 - standards.

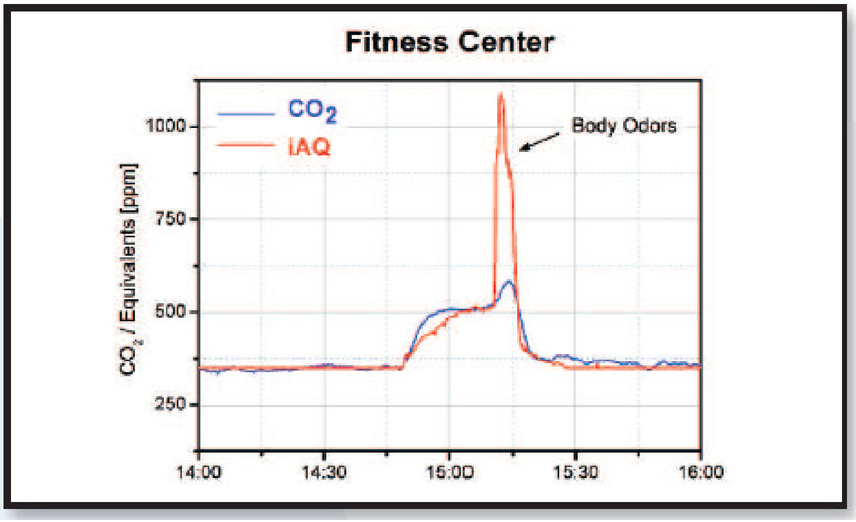
Moreover, the iAQ sensor captures all VOC odor emissions that are completely invisible to CO2 sensors as Diagram 2 demonstrates.

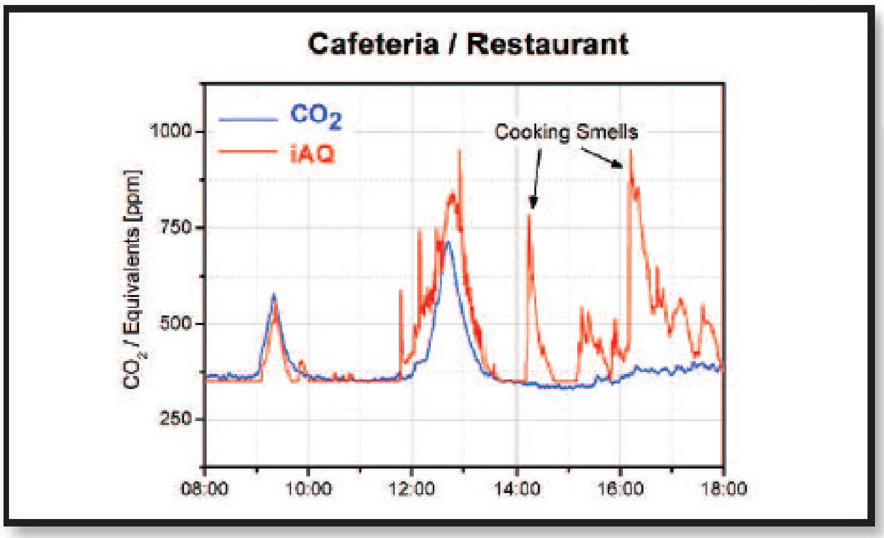
Importantly, BIO sensor control algorithms correct for sensor drift and aging and thereby provide consistency.

The iAQ sensor overcomes deficiencies of CO2 measurement by detecting the true root-cause of ventilation demand, VOCs.

Further, the iAQ sensor remedies deficiencies of typical VOC sensing technologies by signal-adherence to established CO2 standards and stringent drift compensation for extended sensor life.

The iAQ sensor emulates the human perception of air quality and even detects odorless, potentially hazardous substances such as carbon monoxide.





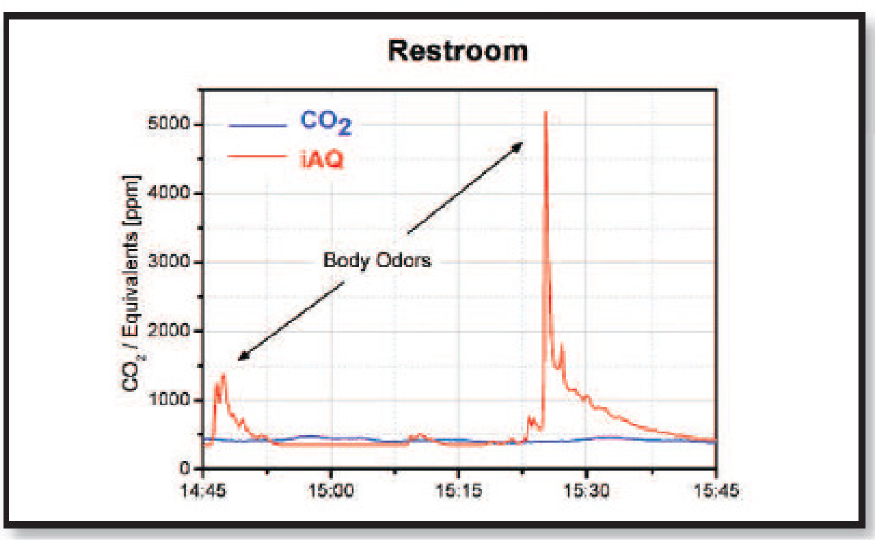


Diagram 2 – Typical scenarios where CO2 sensors fail as DCV reference

Which Reference to Follow

Today, various types of DCV sensors are available including occupation detection, CO2 detection, humidity measurement and VOC sensing. Table 3 compares the performance of the latter three air quality sensor technologies over various applications, clearly depicting the advantage of BIO sensor 's intelligent Air Quality technology.

Application	COMMERCIAL						RESIDENTIAL		
	Office	Conference Room	Restaurant	Gym	Restroom Toilet	Kitchen	Livingroom	Bedroom	Bathroom Shower/Bath
Predominant Event(s)	breath, odors	breath, odors	breath, odors, humidity	breath, odors	odors	odors, humidity	breath, odors	breath, odors	humidity
Humidity Sensor	Poor	Poor	Fair	Poor	Poor	Fair	Poor	Fair	Excellent
CO_2 Sensor	Good	Good	Good	Fair	Poor	Poor	Good	Good	Poor
iAQ Sensor	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Fair

Table 3 – Performance of various Air Quality Sensors over typical ventilation scenarios

When and How to Ventilate

The answer is: **on demand**. Most VOC events are unpredictable as they are dominated by human metabolism and behavior, which accounts for more than 85% of all ventilation cases.

The remainder comes from building material emissions common in new buildings and after refurbishments or from furnishings and coatings.

To dilute these emissions sufficiently, low-rate, permanent ventilation at 5-10% of maximum is adequate.

Table 1 lists relevant substances and recommended ventilation scenarios.

VOC emissions rarely occur in isolation; therefore, a combination of both ventilation types is the ideal solution.

What to Save By DCV

There are many options to achieve energy savings in ventilation.

Ventilation systems can be operated permanently with constant air volume, CAV, statistically with variable air volume, VAV, and on-demand, DCV.

DCV, however, has many control options to choose from: occupation, CO2, VOC, and humidity are today's typical reference variables in use.

Tests conducted at a fitness center comparing the iAQ sensor against timer-controlled ventilation installed in an air handling unit showed 24% less operating time, which translates to a 60% energy cost savings.

Visitors to the fitness center gave the air quality improved ratings.

Demand controlled ventilation with BIO sensors iAQ technology means maintaining excellent indoor air quality and occupants' health at minimum cost.

Wide Variety of iAQ Applications

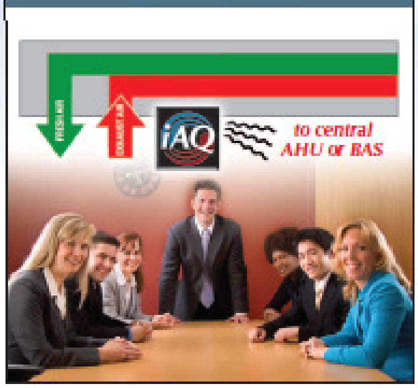
There are many opportunities for improving the quality of indoor air and reducing energy usage in new or retrofitted legacy DCV systems by deploying BIO sensor´s iAQ sensors.

Some of these applications are illustrated below.

Commercial/Residential

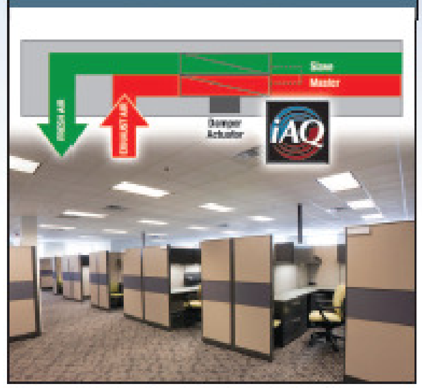
iAQ–Integrated Wall Controller Reporting to Central AHU or Building Automation System (BAS)

Commercial



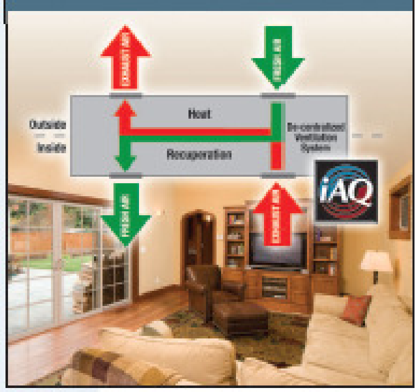
iAQ–Integrated Duct Control Reporting to Central AHU or Building Automation System (BAS)

Commercial



iAQ–Integrated Air-Out Damper Actuator in Master/Slave Connection with Air-In Damper Actuator

Commercial/Residential

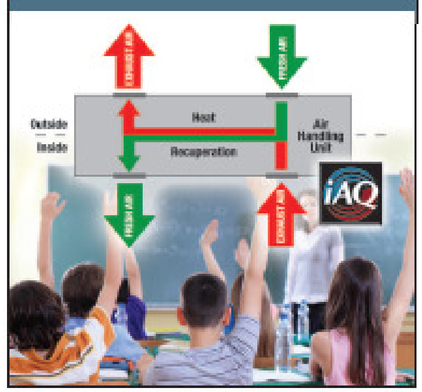


iAQ–Integrated De-Centralized Ventilation System

Commercial/Residential

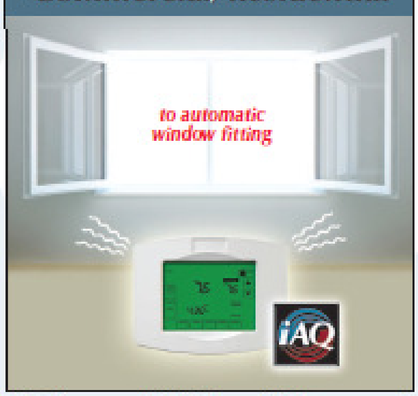
iAQ–Integrated Bathroom/Restroom Ventilation System

Schools



iAQ–Integrated Standalone Air Handling Unit (AHU)

Commercial/Residential



iAQ–Integrated Wall Control for Automated Window Ventilation

Residential/Consumer

iAQ–Integrated Air Quality Indicator to Provide Suggestions for Manual Ventilation (Open/Close Window)

Residential/Consumer

iAQ–Integrated Air Cleaner