

Precision Agriculture

Improve Productivity
Increase Energy Efficiency
Speed up Growing Cycle



**C02 Level Control System by
ZigBee Wireless C02 Meter
Application Note**

S05-C02-HSB / S05-C02-MSB

SR-C2-0120
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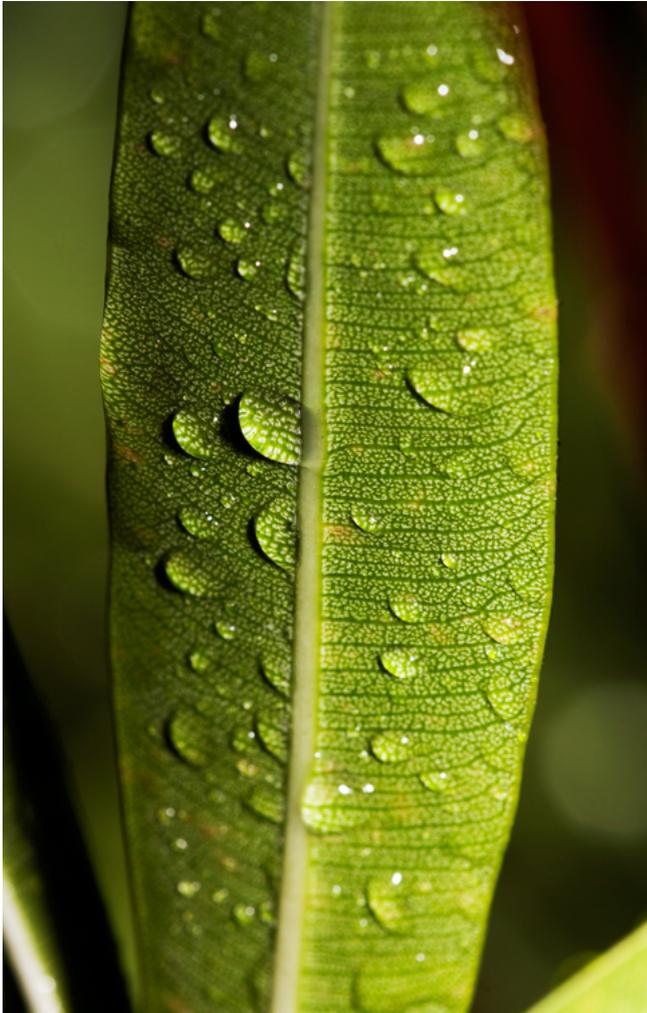
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Why CO2 Level monitoring in horticulture



Role of CO2 for plants

Throughout the earth history, the carbon dioxide(CO₂) concentration was much higher than it is now. And it is certainly above 1000 parts per million (ppm) when plants appeared and have transformed. As the mater of fact, the CO₂ concentration is about 350 ppm in outdoors air now, therefore, plants grow better and are stimulated by inhaling air with high CO₂ concentration.

That is very straightforward to see so many growers saturate their plants, fruits, exotic flowers..etc. with CO₂ during the period of photosynthesis, in the middle of process, carbon in CO₂ is extracted and takes part in the building of stems, leaves, fruits and flowers. Appropriate CO₂ level throughout the entire growing process allows for speeding up growing cycle and more productivity per growing unit.

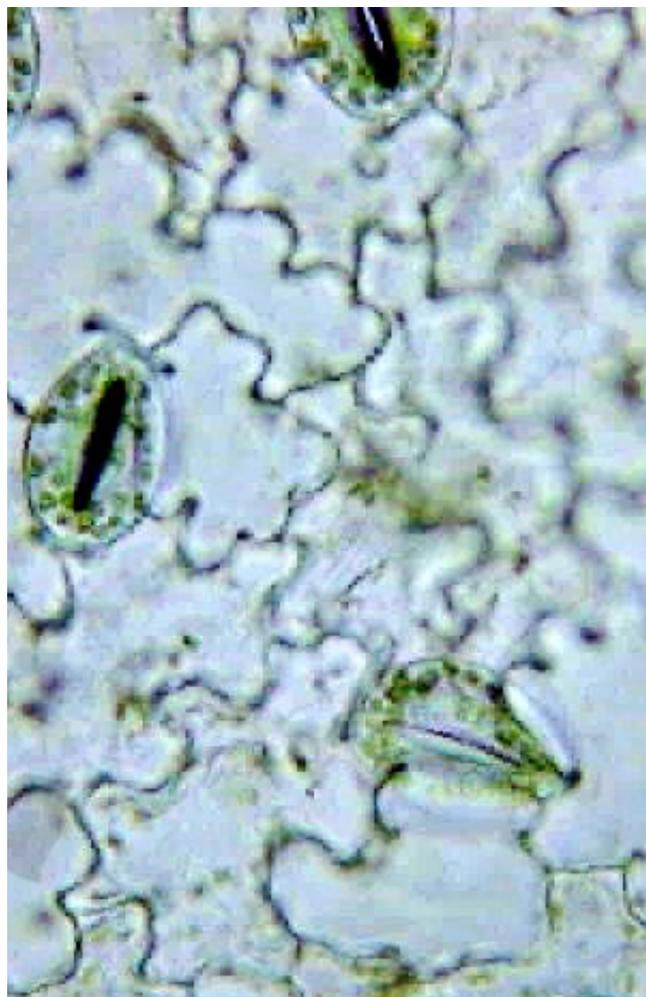
The benefits of CO₂ enrichment are for the purpose of reducing the time from seedling to harvest, and generally accelerate growing cycle and larger yield. Plants also are better protected some pests like moulds. Researchers compared Romaine lettuce grown outdoors and in a climate controlled greenhouse with CO₂ enrichment. The maturity cycle days between CO₂-controlled greenhouse and not controlled open field are 14 days, CO₂-controlled is faster; and the crop yield weighted 33% for controlled is more than the open field. The results were clearly to the advantage of the indoor greenhouse grown lettuce where CO₂ concentration was properly controlled.

Theory behind CO₂ absorption by plants

Flowers and plants leaves have thousands stomas per square inch to let the plant breathe gases such as CO₂, oxygen and water vapor. They get the carbon atoms only when they breathe the air via their stomas. As soon as stomas close, they utilize carbon essential material to build the vegetal cells.

Most major nutrients to plants are absorbed via the roots. If one essential nutrient is not in the proper proportion relating to all others, it becomes the limitation that causes growth slowing down.

Most of the time CO₂ and carbon availability become the limitation. Specific mix of temperature and humidity are two key factors to keep the



▲ Leaves stomas

What Nietzsche Delivers

Nietzsche has led the way in the development of automated control via wireless sensor for the horticultural industry. Precision climate control, low energy consumption and total cost of ownership in installation have always been Nietzsche's main drivers in developing the technology.

stomas opened at all times for the flowers to breath in Co2 during photosynthesis (when there is light) and exhale gaseous surplus and waste at nights.

It is useless or even harmful to raise the CO2 enrichment when the plants are in the dark. When there is no light, plants breath out all left over gaseous materials not utilized during photosynthesis. Some CO2 is also breathed out. So, raising the CO2 level in the dark may cause a conflict sabotage the plant's cleanup in preparation for the next photosynthesis period.

In summary, to improve the productivity and faster growing cycle, it is very important to keep the stomas opened as much as possible by controlling indoor/greenhouse climate right time, volume as close to the optimal level.

How much CO2 is sufficient?

Growers those who adapt CO2 controlling technology keep the CO2 concentration between

700 to 900 ppm to improve crop growth and yield. For some specific plants that may require 1100 ppm or even higher to reach the goal.

However, too high in CO2 level is NOT good to the plants. Growing process may slow down in that less nutritive solutions is drawn thru the plant because of less transpiration during photosynthesis as the CO2 enrichment exceeds what the plants need. Moreover, under too high CO2 level, dead vegetal tissue appear on leaves and then spreads out. These dead tissue spots are a good source for bacteria and molds. That too much of a good thing may turn out reducing the yield per plant and That can also be a waste of money

Raising the CO2 level when the plants are in the dark is useless and harmful to plants. In the dark, plants reject all left over gaseous materials not integrated during photosynthesis. Some CO2 is also rejected. So, raising the CO2 level in the dark may cause a "jam" preventing the plant's cleanup in preparation for the next photoperiod.

CO2 Safety Warning

Carbon dioxide (CO2) is not toxic in itself. However, the higher the CO2 level, the more the human breathing and brain functioning are affected. But for the hazardous high levels in excess of 6000 ppm, the CO2 causes discomforts for human. The affected person just has to go breathe in a lower CO2 level place like outside until the discomfort disappears as the CO2 level in blood lowers.

What Nietzsche's S05-C02 and Sentrolcloud can do?

Sufficient accuracy and long term stability

The S05-C02 wireless Zigbee carbon dioxide(CO2) sensor is using the world class infrared absorption method, Non-dispersive infrared sensor technology, with sintered filter case allowing sensing in high humidity. This ensures reliable and accurate carbon dioxide measurement in long term stability.

Degree protection IP66/NEMA4 Operable in high relative humidity (SGS certified)

S05-C02 has been approved by SGS that the wireless transmitter has protection level at IP66/(Equivalent to NEMA4) which is suited to high humidity environment up to 99% RH. The probe of CO2 sensor has stainless sintered filter protection allowing the sensor to be sustainable at high humidity environment up to 95% RH Non-condensing.

Self-healing capability for wireless sensor network

Nietzsche's wireless sensor network has automatically beacon function whenever there are random factors that causes disconnection, such as interference by other radio, or suddenly power shut-down or gateway has been replaced manually...etc. That allows users to have peace of mind for the reliability of sensor network.

High sensor response time

It is very easy to set the interval of transmission over each sensors. Installers simply use the binary switch inside the S05-C02 according to their own

application requirements.

Anti-UV in housing and RoHS parts selection to create sustainable product

The S05-C02 has Anti-UV housing to protect the PCB inside to function well over long period of time. With that feature, the sensor can be placed at outside for field examination as weather station monitoring CO2 level continuously without problem.

Automated climate control and SMS instant alert

NHR is a world leader in the development and supply of sustainable technologies for the control of indoor environments for horticulture and buildings. S05-C02 can come together as a system with Sentrolcloud, G07 gateway controller and A08 power meter and actuator. The Web-based sensor cloud monitors continuous sampling, and provides instant SMS for early warning. G07 ZigBee wireless gateway controller can control A08 (ZigBee wireless relay) when the inside concentration drops, relaying CO2 generators bring the level back to optimal conditions.

Customized sensor calibration interval and ease of calibration

Nietzsche provides PC software for installer to calibrate sensor when the drafted readings have been observed. That provide extra value to install when a calibration work has to be done and with the tool, installers can do it quickly and effectively.



▲ Wireless sensor hanging at the top of advanced greenhouse

Potential wear and tear of moving parts

The CO2 sensor probe can be replaced when the sensor has been observed as EOL (End of life). That provides better return on investment when user only want to replace sensor probe instead of replacing the whole unit (ZigBee transmitter and sensor probe).

Compatibility of the sensor signal output with our current control system

S05-CO2 can also be seamlessly integrated into a process computer(PLC/IPC) with standard ModBus RTU protocol via USB dongle, RS485 receiver, RJ45 Ethernet receiver...etc. and other customized

interface. That provides the excellent value in compatibility of the sensor signal.

Quick deployment and high resolution sensing

With S05-CO2, the CO2 level in greenhouse atmosphere can be continuously sampled from multiple locations, up to 100 nodes from one G07 gateway for intelligent process control. Leveraging its wireless technology, it is very straightforward and time-saving to deploy all the sensors.

Product Introduction

Product Description

The S05-CO2 ZigBee Wireless CO2 Sensor is a user-friendly meter for demanding spot measurements in a focal environments, and as a tool for checking CO2 concentration continuously. In this model, the accuracy has been optimized for CO2 concentrations up to 10000 ppm.

This product is designed not only to measure carbon dioxide (CO2), but to control concentration levels in different environments, both indoors and outdoors.

The value in applying in greenhouse is to increase CO2 levels by controlling valves on make-up CO2 tanks, among other functions that help improve vegetation growing conditions by automating critical processes, normally CO2 level is around 1200 ppm ~ 1600 ppm .

The S05-CO2 also supports the use of Sentrolcloud automated platform, making it a sound investment applicable to several multi-parameter applications. Seven types of probes can simultaneously be displayed to the dashboard for real-time monitoring.

The product can also support stand-alone PC software, DataView(for ZigBee HA protocol); or QuickView(For ModBus RTU protocol) via ZigBee USB dongle to form a practical way for transferring logged and real time measurement data from a local PC.

Apart from greenhouse, the sensor can be applied



in below 3 three areas :

(1) Indoor air quality (IAQ) where the sensor can control a fan, a damper, or any other HVAC component to reduce CO2 levels in the area being monitored, normally CO2 level is around 0 ~ 1000 ppm.

(2) Help assure Occupational Safety and Health Administration (OSHA) limits and guidelines will trigger alarms when dangerous CO2 levels are reached in indoor, enclosed areas, normally CO2 level is around 4000 ~ 6000 ppm.

(3) Fermentation and incubation applications where the CO2 level will be determined by field experts.



▲ Wireless sensor at vegetation greenhouse

Where to Place CO₂ Sensor Probe?

The sensor mounting height depends on the density of the gas relative to air. Heavier than air gases should be detected 6 inches from the floor, lighter than air gas sensors should be placed on or near the ceiling, and gases which have a density close to that of air should have sensors installed in the "breathing zone" 4 - 6 feet from the floor.

CO₂ has a density close to air, the breathing zone refers to the area 4 - 6 feet from the floor, where most human breathing takes place. This is a good default location for sensors, as many gases are often well dispersed in air.

In greenhouse, particularly, sensors probe should be placed near the source of the gas if possible. For example, near the plants or flowers.

The readings of carbon dioxide measurements are affected by the air pressure and the

temperature of the measurement situation. For achieving the more accurate measurements in high altitudes where the barometric pressure is clearly lower than in the sea level, installer must seek support from local professional to conduct necessary readings calibration. The acceptable pressure range is about 750 to 1200 hPa.

They should be placed in areas where there is good air circulation, but not in the path of rapidly moving air. Pay particular attention to "dead air spots" where there is little or no air movement. After installing the probe, please wait the reading to stabilize after 15 minutes.



▲ Wireless sensor hanging in greenhouse

S05-CO2 Outlook



Operation and LED Indication

step

1

Package Content and S05-C02 Inspection

S05-C02 Inspection

S05-C02 ZigBee wireless CO2 sensor



**Mounting fixtures
(mounting cradle, 2 wall plugs, 2 screws)**



Power Adaptor



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step

2

Installing Mounting for S05-C02

Requirements :

- Mounting fixtures
- Drill with 5mm (0.2 inches) drill bit size (if using wall plugs) or 3.5mm (0.14 inches) drill bit size (if not using wall plugs)
- Size 1 Phillips screwdriver

a) Locate S05-C02 with at least 15cm (approx. 6 inches) spacing on each side (except on mounting side) avoiding the following sources of interference : direct sunlight, air flow from vents,

fans, doors, windows, heaters, sources of steam, oil vapor, etc.

b) If necessary, pre-drill mounting holes using mounting cradle for alignment, then use appropriate drill bit to drill the holes – 5mm (approx. 0.2 inches) if using wall plugs or 3.5mm (approx. 0.14 inches) if not using wall plugs.

c) If necessary, insert wall plugs into the 2 holes and use size 1 Phillips screwdriver to fasten the screws securing the mounting cradle.

Note : pay careful attention to the orientation of the mounting cradle.

d) Install and remove S05-C02 by placing it into and lifting it out of the cradle :

Install



Remove



Initial hardware installation for S05-C02 has been successfully completed.

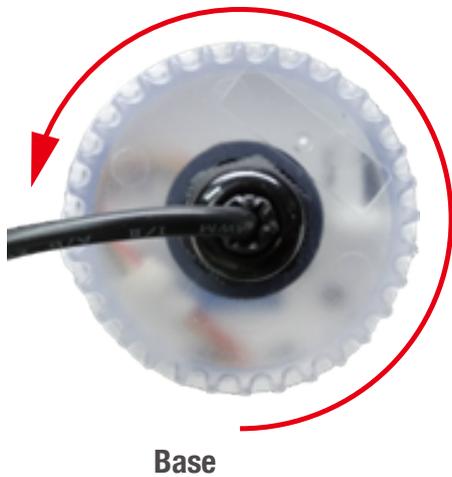
step 3

Installing and Power On S05-C02

Requirements :

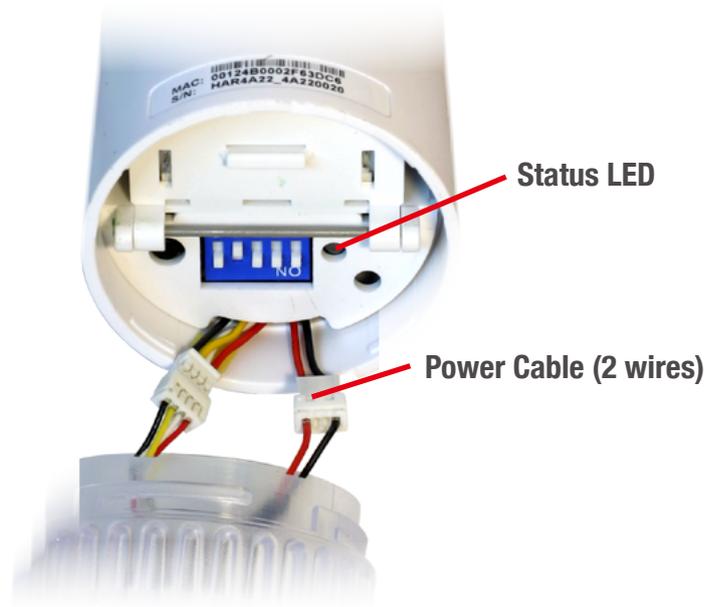
- Plug in power adaptor

a) If necessary please open the base by twisting it



counterclockwise to make sure the power connection inside the transmitter is well-connected.

b) The status LED on S05-C02 should start flashing to indicate its current state :



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Specification	
Green LED	Status
1 flash per second	Ready to join a parent device
1 flash every 60 seconds	Already joined a parent device and functioning normally
2 flashes every 5 seconds	Already joined but unable find a parent device in the same network

c) Complete the inspection by twisting it clockwise until it is firmly secured to the transmitter.

step 4

Setting Transmission Interval for S05-C02

a) If necessary, remove the S05-C02 from mounting cradle (see “Installing Mounting for S05-C02” section).

b) Twist the base counterclockwise to gain internal access to the transmitter, being careful when separating the base to ensure the sensor cable connector stays connected.

c) Set the transmission interval based on the following DIP switch positions :

Setting Transmission Interval			
Transmit Interval	DIP Switch Setting	Transmit Interval	DIP Switch Setting
1 Second		1 Minute	
5 Seconds		5 Minutes	
10 Seconds		10 Minutes	
15 Seconds		15 Minutes	
20 Seconds		20 Minutes	
25 Seconds		25 Minutes	
30 Seconds		30 Minutes	
35 Seconds		35 Minutes	
40 Seconds		40 Minutes	
45 Seconds		45 Minutes	
50 Seconds		50 Minutes	
55 Seconds		55 Minutes	
60 Seconds		60 Minutes	
65 Seconds		65 Minutes	
70 Seconds		70 Minutes	
75 Seconds		75 Minutes	

d) Ensure S05-C02 is joined to a parent device (see “Adding S05-C02 to the Network” section).

- e) Use software for reading information from coordinator or gateway device (see relevant device's manual) to confirm S05-C02 transmissions are being received at the correct interval.
- f) Replace the base by twisting it clockwise until it is firmly secured to the transmitter.
- g) If necessary, replace S05-C02 into mounting cradle (see "Installing mounting for S05-C02" section). Transmission interval setting has been successfully configured.

Note : Transmission interval is read at power on, a power cycle is required to effect interval change.

steps until S05-C02 has joined successfully. If S05-C02 has still not joined after a few attempts, check it is within the operational range of 500m (line of sight) from the parent device and away from other 2.4GHz devices that might interfere with its operations. If S05-C02 has joined successfully, but is showing disconnected status (green LED flashes twice every 5 seconds), then check parent device is correctly powered on. If the parent device is functioning correctly, S05-C02 may be out of range or experiencing interference, additional router(s) may need to be added to ensure good connections.

step 5

Joining S05-C02 to the Network

Requirements :

- Parent device, such as coordinator (eg. WZB-01USBC, WZB-02485C), gateway (eg. G07, WZB-05ETS), or router (eg. WZB-01USBR, WZB-02485R)
 - Sharp pointed tool
- a) Ensure parent device is powered on (see relevant device's manual).
 - b) Power on S05-C02 (see "Installing and Power On S05-C02" section) ensuring it is in ready to join status (green LED flash once every second).
 - c) Enable permit join status on parent device (see relevant device's manual) and check S05-C02 joined the parent device.
 - d) If S05-C02 has successfully joined the parent device, the green LED should flash 3 times, then once every 60 seconds. If S05-C02's green LED does not flash once every 60 seconds, then it has not successfully joined. Repeat above

step 6**S05-C02 LED Status**

The S05-C02 LED can be seen through the translucent base. The table below shows the LED status for S05-C02

LED Status	
Green LED : 1 flash every second	<i>Ready to join</i> – ready to join network of parent device (coordinator, gateway, or router)
Green LED : 3 flashes (one time)	<i>Successfully joined</i> – joined network of parent device
Green LED : 1 flash every 60 seconds	<i>Normal Operations</i> – joined network of parent device and functioning normally
Green LED : 2 flashes every 5 seconds	<i>Disconnected</i> – joined network, but unable to find any parent device of the network
Red LED : Rapid flashing up to 30 seconds	<i>Removing</i> – being removed from the network of the parent device
Green & Red LED : ON	<i>ZigBee Reset</i> – reset to factory default, remove all ZigBee network linkages

step X

Removing S05-C02 from the Parent's Network Requirements :

- Sharp pointed tool
- a) Ensure parent device (coordinator, gateway, or router) is powered on (see relevant device's manual).
- b) Ensure S05-C02 is powered on (see "Installing and Power On S05-C02" section) and has already joined the parent's network (green LED flash once every 60 seconds).
- c) Twist the base counterclockwise to gain internal access to the transmitter, being careful when separating the base to ensure the sensor cable connector and power cable stay connected.
- d) Use a sharp pointed tool to apply 3 quick presses to the link switch on S05-C02, the red LED will flash rapidly for up to 30 seconds or

- e) until successful removal.

If S05-C02 has been successfully removed, the green LED should show ready to join status (flash once every second).

step Y

ZigBee Reset

In the case where the parent devices (coordinator, gateway, or router) for S05-C02 are no longer available or have been reset, S05-C02 will need to be reset by applying a 5-second press to the link switch, the green & red LEDs will both come on during the reset, then the green LED should show ready to join status (flash once every second).

Specification

Specification	
Sensing Operating Principle	Non-dispersive infrared (NDIR)
Sensing Gas	Carbon dioxide (CO2)
Sensing Range CO2	0 – 10,000 ppm CO2
Sensing Accuracy	±70 ppm CO2 ±3% of reading
Pressure Dependence	+ 1.6 % reading per hPa
Sensor Cable Length	2 meters
Sensor Probe Dimension	8.4 (H) X 2.9 (Φ) cm ; 3.3 (H) X 1.1 (Φ) inches
Sensor Enclosure	Steel sintered filter (Water splashing prohibited)
Operation Temperature Range	0 to +50 °C (32F to +122F)
Operation Humidity Range	< 85 % relakeive humidity (Water splashing prohibited; senor should be always powered on)
Wireless Technology	ZigBee wireless transmission
Wireless Transmission Range	500 meters / 1640 feet line of sight
Communication Protocol	Compliant IEEE 802.15.4, ZigBee2007 / PRO HA Profile / ModBus RTU
Network Topology	Star / Tree / Mesh
Transmit Interval	1 second to 75 minutes, based on DIP switch setting
Operating Frequency	2.4 GHz ISM Band
Output Power	18 dBm
Receiver Sensitivity	-92 dBm
Transmitter Dimension	13 (H) X 5 (Φ) cm ; 5.1 (H) X 1.9 (Φ) inches
Transmitter Enclosure	IP66 grade waterproof & dust tight – SGS Lab. certified

Specification - continued

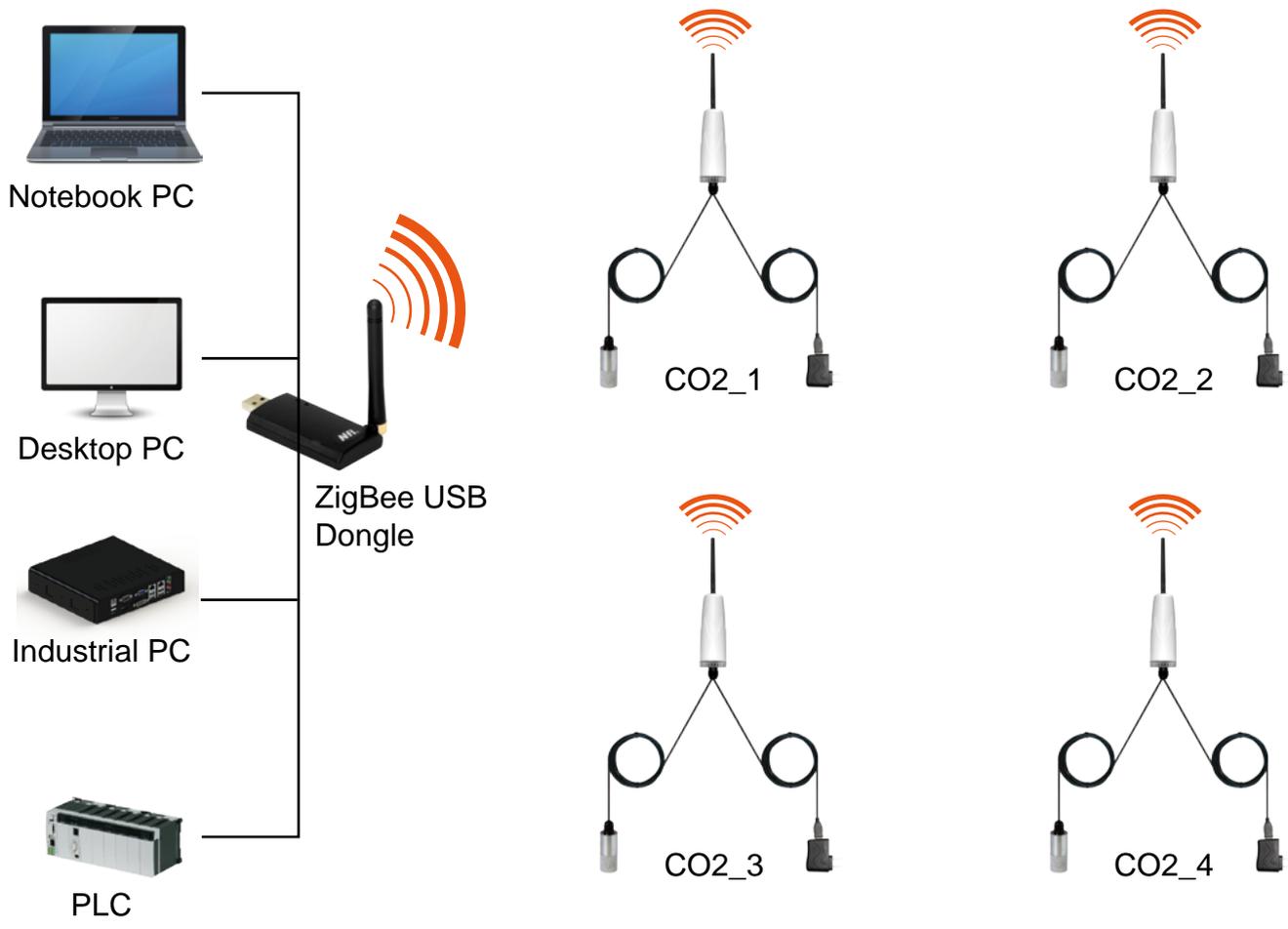
Transmitter Enclosure	IP66 grade waterproof & dust tight – SGS Lab. certified	
Power Supply	Power adaptor 90 ~ 240 VAC / 50 ~ 60 Hz	
Enabling Devices & Software	Coordinator	WZB-01USBC / WZB-02485C
	Gateway	G07 / WZB-05ETS
	Router	S05-R / WZB-01USBR / WZB-02485R
	Software	SentrolCloud system; DataView / QuickView PC software
Certifications	CE/FCC/SGS IP66 testing report	

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System Structure

Local CO2 Monitoring Diagram

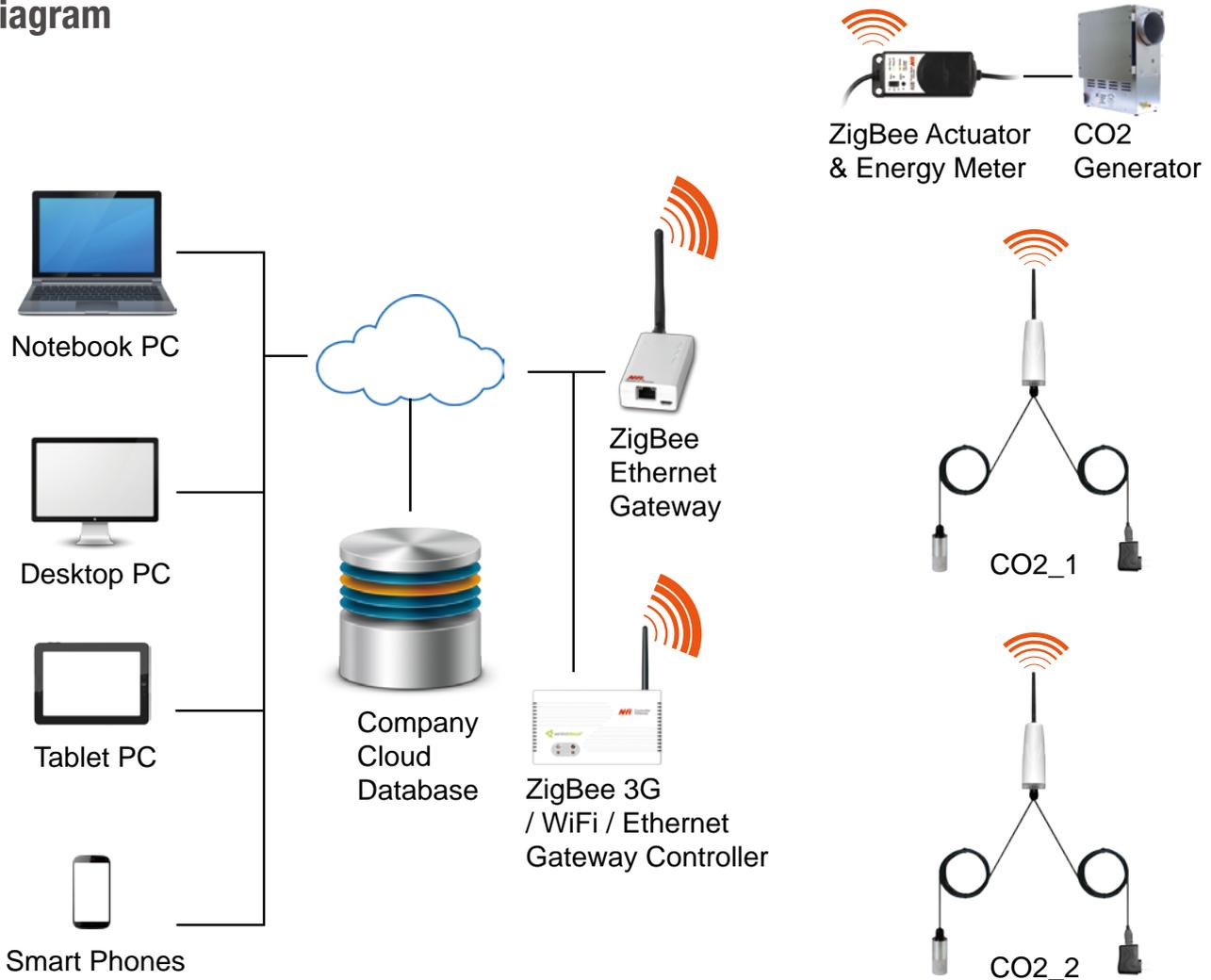


The diagram shows how installer can form a local wireless CO2 system by using S05-CO2 with a single USB dongle. The USB dongle operates as ZigBee coordinator/receiver which receives data packets from S05-CO2 wirelessly, then router to PC, PLC, Notebook PC, Point-of-sale system PC, or other industrial PC.



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Remote CO2 Monitoring and Control Diagram



The diagram shows how installer can form a remote wireless CO2 control system by using S05-CO2 and other network enablers, such as ZigBee Ethernet Gateway, or ZigBee 3G / WiFi / Ethernet Gateway Controller, and A08 ZigBee Power Meter and Actuator. Installer can build up a company database and all the devices can access and configure set-point of CO2 via internet. Once the readings of CO2 has reached the set-points, the gateway controller will send On/Off signal wirelessly to A08 to activate/shut-down CO2 generator for maintaining CO2 level in the focal area. The gateway

controllers operate as PLC controlling all the A08, even when the internet is disconnection. Once the infrastructure has been built, the installer can configure set-points over smart devices, such as smartphone, tablet PC, or other internet-accessible device. The A08 ZigBee Power Meter and Actuator features energy metering function which allows installer to monitor all the necessary power consumption for any CO2 generator, or fans system to monitor energy efficiency and pre-aware possible abnormal operation of output devices.

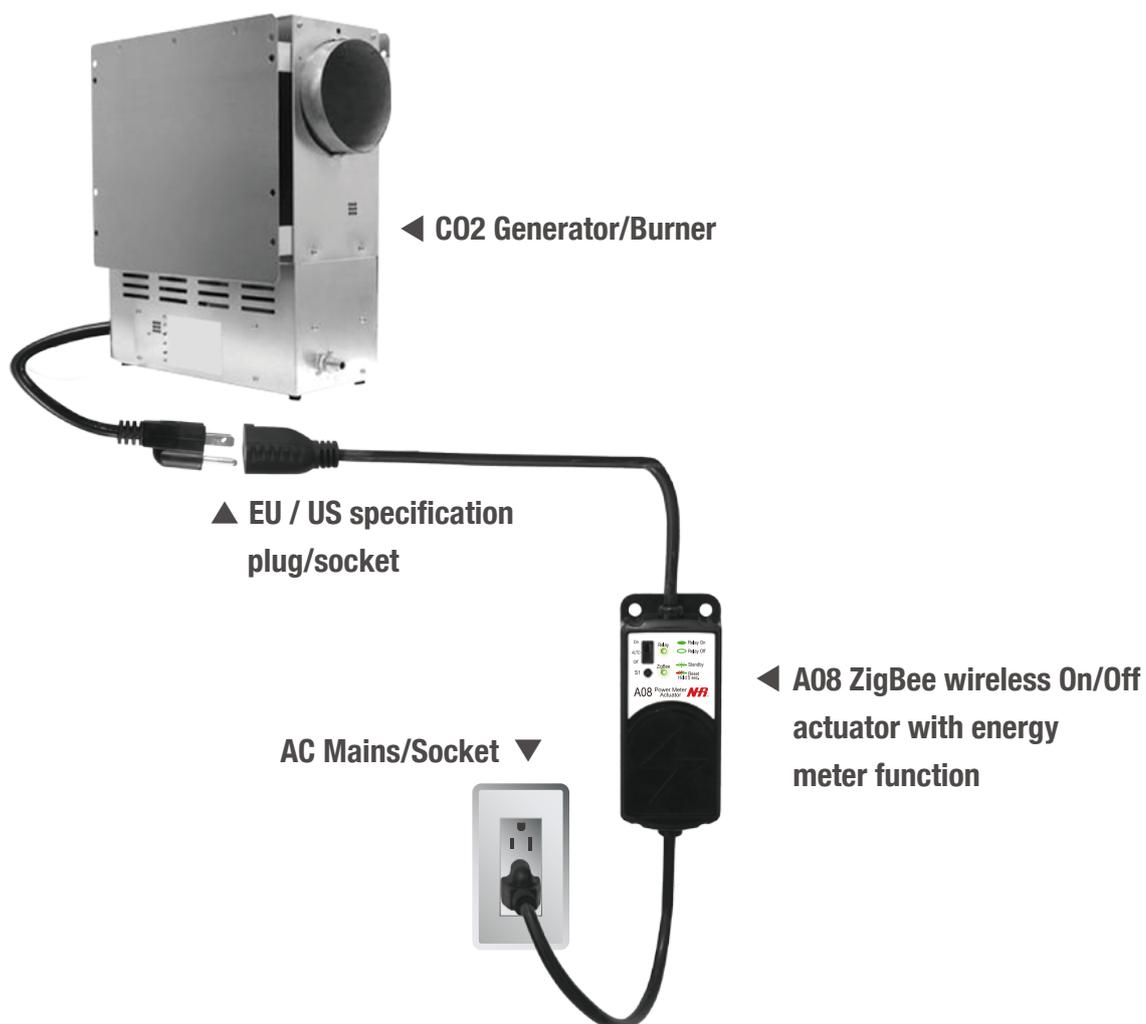
CO2 Control by A08 ZigBee Energy Meter and Actuator

Fans, ventilators, generators, and valves are among the most common devices that can be controlled by this actuator. In order to control these external devices, they have to be properly hardwired to the actuator(A08) and caution must be taken when

connecting these devices to the actuators. **This output is being controlled by a 16-amp relay/ 240VAC. Do NOT exceed the current rating of this relay.**

Caution

Risk of electric shock. Turn OFF actuator power before making this connection





www.shop-wifi.com/wireless-sensors

e-mail: zigbeenhr@shop-wifi.com



Nietzsche Enterprise Co., Ltd. (NHR), est. 1978, is an ISO9001 certified manufacturer, has been engaged in wireless communication and power solutions for over 36 years and continues to focus on meeting current and future market needs in Wireless Sensing Network. NHR's design center and factory are in Taipei, Taiwan, with a commitment to solving constraints from wires and cables through delivering intuitive, convenient, reliable, and rapid return on investment wireless solutions to customers. Products and solutions include agriculture, logistics/transportation, energy & water management, security & maintenance, industrial, asset management, and aquatic.

SentroCloud is a sensor cloud platform for Automated Control and Instant Out-limit Alert. Using a world-leading cloud storage service provider to ensure the data is secure and always accessible from anywhere via any web-enabled computer, tablet, or smart phone, SentroCloud interface puts intuitive monitoring and control at your fingertips allowing for 1-second rapid decision-making and more in-depth trend analysis. For more information, visit our cloud platform at www.sentrocloud.com