KNET-CO2

BACnet and Modbus Networked CO_2 Sensor/Transmitter with Relay

Preliminary

User's Manual

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Feature Overview

The KNET-CO2 is a supervised, network-capable CO_2 sensor/transmitter with a single relay. It can be configured for local concentration based or network-controlled actuation. The KNET-CO2 can communicate using BACnet MS/TP, Modbus RTU, or Modbus ASCII, all using an RS-485 transport layer. The KNET-CO2 has a supervised, dual-beam CO_2 sensor for long-term stability without the need for frequent re-calibration. Configuration of settings is accomplished using the *NEARcom* app with an NFC-capable smartphone for easy 'fill in the blanks' network setup.

CO_2 Sensor

The KNET-CO2 uses a self-compensating 'dual beam', NDIR (Non-Dispersive InfraRed) CO_2 detection system with a second IR detector to measure and eliminate the major inherent drift mechanisms (source amplitude degradation and sensor-wall reflectivity changes) for greatly enhanced long-term accuracy. To achieve comparable performance, single beam systems need 'self-calibration' algorithms that can be wildly inaccurate in changing building occupancy profiles. The KNET-CO2 can be used in any building occupancy profile with no compromise in long-term accuracy.

The gas detection system is internally supervised, so the KNET-CO2 will immediately notify its controller in the unlikely event of failure.

Relay

The KNET-CO2 has a dry-contact, 2-Amp rated, Single-Pole Double-Throw (Form C) pilot relay that can be controlled by two different mechanisms; local setpoint or network control. With *Setpoint Control*, the relay is controlled locally by the device based on its current CO_2 setpoint. *Network Control* passes control of the relay to the active network interface where it is modeled either as a binary output (BACnet) or a holding register (Modbus).

BACnet

BACnet (Building Automation and Control network) is a standardized communication protocol used for building automation created by ASHRAE (American Society of Heating, Refrigeration, and Air-Conditioning Engineers). BACnet specifies a vendor-independent set of models and messages that enable equipment from multiple manufacturers to be integrated within the same control network. BACnet can use several different physical communication systems depending on the constraints of the system, the most common being BACnet/MSTP and BACnet/IP. Most end devices only support one transport layer; bridges are available that can translate messages between different transport layers.

The KNET-CO2 supports only BACnet/MSTP using RS-485.

Modbus

Modbus is an industrial control protocol. It has somewhat less overhead than BACnet, allowing fewer data types and providing less context information about modeled objects. In Modbus all data is held in registers that can be read or written to interact with the values they model (e.g., CO_2 reading, relay state, etc.). A single client device sends requests to servers such as the KNET-CO2. Servers will not initiate communication unless they are directly addressed.

Modbus supports several modes of communication; RTU, ASCII, and TCP all using the same data model. Modbus RTU (remote terminal unit) and Modbus ASCII both use asynchronous serial communication protocols for their physical layers (typically RS485) and differ mainly in how data is encoded, RTU being more efficient and ASCII being somewhat more readable.

The KNET-CO2 supports Modbus ASCII & RTU only via RS-485.

Network Topology

The KNET-CO2 uses RS-485 as its physical transport layer. Individual network elements are connected with a single twisted-pair of conductors, often covered by a metal shield. All network elements are wired in a 'daisy chain' configuration as shown in Figure 1. Only the units at the ends of the chain have a terminating resistor connected between the two data lines.

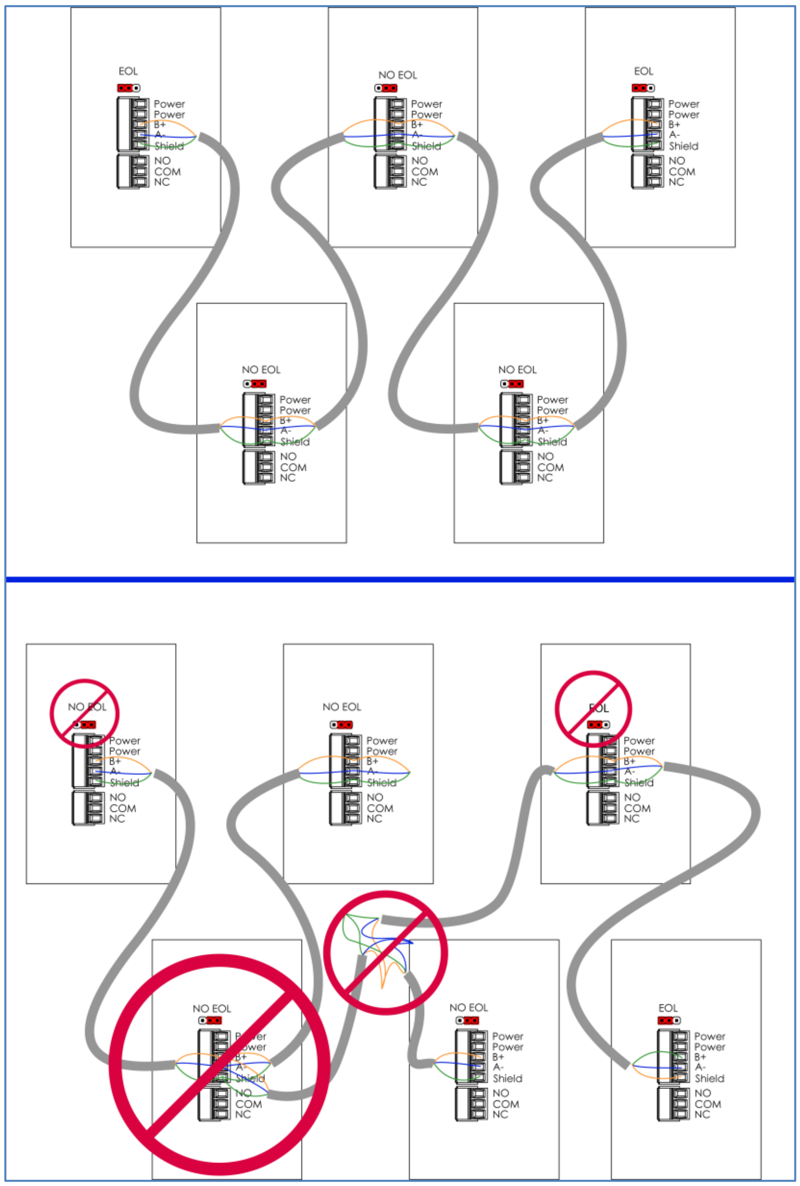

Figure 1: BACnet Network Topology

Top: Properly routed network with no stubs and EOL termination only at the two ends of the network.

Bottom: Improperly routed network with branch and stub connections as well as improper termination (both enabled mid-chain and disabled at the terminals).

NEARcom

NEARcom is a free app for Android (Android 14 or later) and Apple (iPhone 7 or later) phones equipped with near-field communication (NFC). NEARcom creates a virtual front panel for the KNET-CO2 on a smart phone, and allows the user to view and make changes to the device's settings.

Using the NEARcom app is simple and intuitive: the user simply launches the app and briefly holds the phone near the front of the KNET-CO2 to read the device's current settings. After reading the KNET-CO2, the user can take the phone away from the device to view and make any desired changes to the settings. After all setting adjustments are complete, the user briefly holds the phone near the front of the KNET-CO2 and the new settings are transferred back to the device.

Changes to the KNET-CO2 using the NEARcom app can be made while the device is unpowered (prior to installation) or while the devices is powered and operating normally.

Refer to the Configuration section for more detailed information.

Calibration

Although the dual-beam CO_2 sensor does not need frequent calibration the KNET-CO2 supports a single-point calibration using 2000 ppm CO_2, balance air or balance nitrogen calibration gas.

Calibration gas is distributed compressed in cylinders with pressures above 100 psi. To create the low pressure, weak flow gas stream fed to the CO_2 sensor requires a pressure regulator that fits onto the cylinder supplying the calibration gas and delivers the low-pressure output stream into the ¼" OD plastic tubing that connects to the KNET-CO2's calibration nipple. This collection of apparatus, called a 'calibration kit', is available from Kele.com under part number KCAL-2000.

Accurate control of the flow rate of calibration gas into the sensor is essential for accurate calibration. A flow rate of 100 to 150 ml/min (milliliters/minute) is ideal. Significantly higher flow rates risk bursting the filter membrane at the sensor's diffusion port.

Specifications

Parameter	Value
Communication protocols	BACnet MS/TP, Modbus RTU, Modbus ASCII
Supported baud rates	9600, 19200, 38400, 76800, 115200
Gas Sensor	Supervised, Dual-beam, non-dispersive infrared (NDIR)
Gas Sampling Method	0.5 micron filtered diffusion
Measurement Range	0-5000ppm
Repeatability	± 20 ppm CO_2
Measurement Accuracy	Greater of: ± 50 ppm or ± 5% of reading
Calibration	One point, single gas calibration
Recommended Calibration Interval	5 years
Warm-up time	Initial readings within 15 seconds Full accuracy in 5 minutes
Power Requirements	15 - 40 VDC or 18 - 28 VAC RMS
Power Consumption	Less than 3 Watts
Operating Temperature Range	0 - 50° Celsius (32 – 122 ^{0}F)
Operating Humidity Range	5 - 80% continuous; 0-95% intermittent [RH] non-condensing
Enclosure Dimensions	4.5" x 2.8" x 1.0" (116 x 72 x 25 mm) Wall mounting
Enclosure Material	White Satin Finish, thick wall ABS Plastic UL 94 V-O Flammability Rated
Relay	SPDT, Dry contact, Max rating 2A at 24VDC or 24VAC
Warranty	3-year for sensor, 7-year for electronics

Table 1: KNET-CO2 Specifications.

Installation

Mechanical

The KNET-CO2 mounts most conveniently onto a standard single-gang electrical box, with wiring entering the enclosure through the access opening in its base. The same mounting holes can be used to affix the KNET-CO2 onto any flat vertical surface with appropriate fasteners.

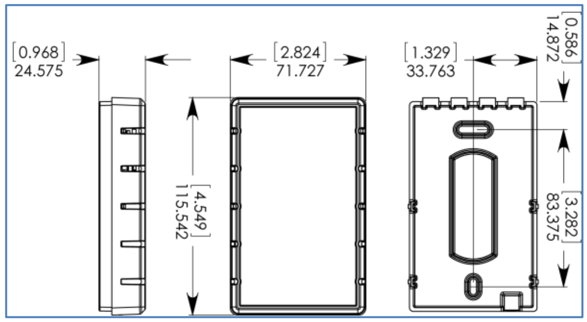

Figure 2: Case Dimensions (mm &[in]).

The unit is specified for vertical mounting as shown in Figure 2, but **will function, at only slightly degraded accuracy, in any orientation**.

Wiring

Feed wires through the enclosure base, then mount the base onto a junction box or directly to the wall.

Connect wires to screw terminals on the circuit board as shown in **Figure 3**. The screw terminal connectors are removable for easy wire landing and keyed so that they can only be inserted back into the correct socket in the correct orientation.

Align the slots in the cover with the tabs on the base and snap enclosure cover closed. Back the set screw (on the bottom of the cover) out to secure enclosure cover using a 3/32" Allen wrench.

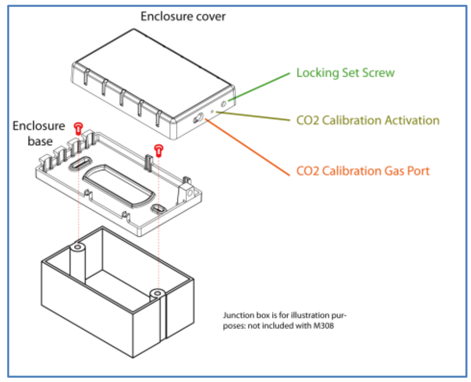

Figure 3: Attaching to single gang box.

Power

The KNET-CO2 is typically powered from a polarized, nominal 24 VAC source. One side of the supply is be tied to earth ground. This lead is designated common, often a white wire and nomenclated as 'COM' or just 'C'. The other power supply lead is often a red wire labeled 'HOT' or just 'H'.

It is critically important that all network devices are powered with the 'HOT' power lead connected to the 'HOT' power terminal and the 'COM' lead to the 'COM' terminal.

For installations without low-voltage operating power, or power of uncertain polarity, the simplest and safest solution is to connect each unit to its own power-line-driven, Class 2, 24 VAC step-down transformer. The secondary must be earth grounded, identified as the 'common' lead and connected to the 'COM' terminal of the unit as shown in Figure 4.

Relay

The Single-pole double-throw (SPDT) relay connection terminals are shown in Figure 4 This is a low-voltage pilot-relay – **DO NOT CONNECT TO LINE VOLTAGE**.

When the relay is inactive the common (COM) terminal will be connected to the normally closed (NC) terminal and the normally open (NO) terminal will not be connected.

When the relay is active the common terminal will be connected to the normally open (NO) terminal and the normally closed (NC) terminal will not be connected.

Network Connection

The network (BACnet or Modbus) data lines should be connected in a daisy chain configuration with no stubs or branches as shown in Figure 1.

The RS-485 network uses a 3-conductor data interconnection: a twisted-pair (A- and B+) and a metallic shield. The twisted-pair conductors are **not** identical and **must not be confused with each other during installation**.

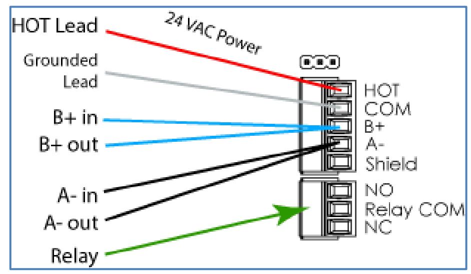

Figure 4: Wiring diagram showing connections

In all installations (except for the last unit on the current segment) there will be an incoming and an outgoing data pair and their shield or drain wires.

It is critical that both incoming and outgoing A- conductors are connected to the A- terminal, and both incoming and outgoing B+ conductors to the B+ terminal.

If the unit being installed is the last one on the segment (i.e. there are only single A- & B+ wires) the end-of-line resistor should be enabled by setting the EOL jumper (see Figure 5) to the EOL position with the shorting block on the left.

Only the end devices in the daisy chain should have EOL termination enabled.

The shield connection terminal is provided for convenience in connecting the cable shields or drain wires together. The shield is not electrically connected to the KNET-CO2 and using the connector to couple the shields is optional, but **electrically connecting the two shields or drain wires is absolutely required.** The shield is left floating at the end unit.

The shield for the entire segment should be tied to ground only at a single end-point, typically the BAS.

Do Not connect the shield to the 'COM' terminal.

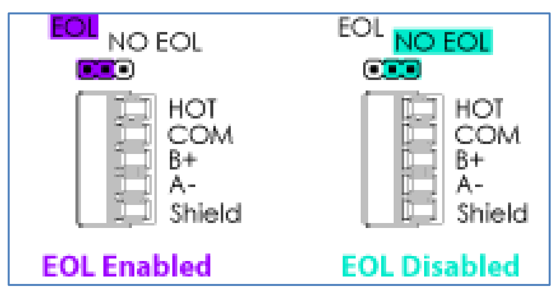

Figure 5: Data line termination jumper
LEFT: EOL termination enabled
RIGHT: EOL termination disabled

Configuration

Figure 6: Links to download NEARcom app.

Because of the relatively complex setup required to configure a networked sensor, the configuration is done through a graphical user interface (GUI) on an Android (Android 14 or later) and Apple (iPhone 7 or later) phone running the NEARcom configuration app. The free apps can be downloaded from the Google Play or Apple App stores using the QR codes in Figure 6.

NEARcom

The NEARcom app uses Near Field Communication (NFC) technology to provide a short-range "touch" link with a mobile device to allow configuration, monitoring and adjustment of the KNET-CO2. Its settings are transferred to the phone by touching the phone to the front cover (with the middle-back of the phone near the area indicated in **Error! Reference source not found.**8). After the transfer is acknowledged, the phone can be taken away so the current configuration settings can be reviewed and changes made while holding the phone in a comfortable position. After making changes the phone is placed near the antenna again to transfer the changes to the KNET-CO2 (refer to the blow procedures for more information).

The configuration settings can be reviewed and changed while the KNET-CO2 is unpowered, allowing the device to be configured, unpowered, on the bench, prior to installation.

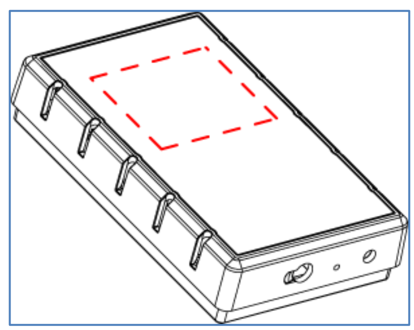

Figure 7: Approximate location of the NFC antenna

Inspecting the KNET-CO2 Settings

Before proceeding, download and install the NEARcom app from the Apple App-Store or from the Google Play Store (QR codes in Figure 6).

1. If an Android phone is being used, ensure NFC is turned on: refer to the phone's manual for more information.
2. Locate and launch the NEARcom app; the app will display "Read settings to make configuration changes."
3. Press the "Read" button located at the top of the app; the app will instruct the user to hold the phone over the KNET-CO2.

Hold the middle-back of the phone near the area indicated in **Error! Reference source not found.**8. After the transfer is complete, the phone can be moved away from the KNET-CO2, and the app will display all of the KNET-CO2 current settings.

Configuring the Device Settings

1. Follow the steps outlined in Inspecting the KNET-CO2 Settings section above. No setting configurations are allowed until the current device settings have first been retrieved.

   Locate the setting to be adjusted. Select a setting by touching it, then make the desired changes: multiple settings can be changed before transferring them back to the KNET-CO2.
   When settings are changed, their fields will be highlighted to indicate they will be updated during the next Write transfer

2. Press the "Write" button located at the top of the app: the app will display a message instructing the user to hold the phone over to the KNET-CO2 to transfer the new settings.
   NOTE: the "Write" button will be grayed out and inactive until a change to the settings have been made.

3. Place the middle-back of the phone over the area indicated in Figure 7 and hold it in this location until the prompt is removed.

   NOTE: moving the phone away from the KNET-CO2 too early will abort transferring the new setting and an error message will be displayed. If this occurs, dismiss the error message, place the phone over the KNET-CO2 and hold it place until the transfer is complete.

Network	Parameter	Value	Description
Both	Baud Rate	9600, 19200, 38400, 76800, 115200	Network Communication speed
	Communication Mode	BACnet, Modbus	Network type selection
BACnet	MSTP Address	0 to 127	Must be unique in its MSTP segment and less than or equal to the value of MSTP Maximum Master
	Maximum Master	1 to 127	Must be greater than or equal to MSTP Address
	Device Instance	1 to 4194302	Must be unique in the entire network
	Device Name	Limited to 50 characters	Text field for user input of a device name (not required – can be blank).
	Device Location	Limited to 50 characters	Text field for user input describing the device's location (not required).
	Device Description	Limited to 50 characters	Text field for user input describing the device (not required).
Modbus	Modbus Mode	RTU, ASCII	Transmission mode of network messages
	Modbus Address	1 to 247	Must be unique on the subnet
	Modbus Parity	Even, Odd, None	Communication parity bit. Setting must match other units.

Table 2: Configuration parameters for BACnet and Modbus networks

Device Config. Parameters	Value	Description
Relay Control Method	Remote or Setpoint	**Remote**: the network has control of the KNET-CO_2 relay actuation. **Setpoint**: the KNET-CO2 has control of relay actuation based on the value of CO_2 Alarm Setpoint.
CO_2 Alarm Setpoint	0 to 5000 ppm	The KNET-CO2 relay will actuate when the CO_2 concentration rises above this setting (refer to *Relay* in the Operation section for more details).

Table 3: KNET-CO2 Configuration Parameters

Configuration Procedure

Before beginning the configuration process:

1. Determine and record the parameter values needed for your installation: a list of the parameters for a BACnet or Modbus network is shown in Table 2.
2. Determine how the KNET-CO2 relay will be controlled (refer to Table 3 for more information).

   NOTE: All KNET-CO2 network parameters for any previously configured units can quickly be determined; refer to *Inspecting the KNET-CO2 Settings* in the *Configuration* section of this manual.

Example configuration – BACnet

For this example, the KNET-CO2 is being configured while it is unpowered (prior to installation). The process is the same if the KNET-CO2 is powered; however, the installer should ensure the MSTP Address and Device Instance are unique before the KNET-CO2 is attached to an existing network.

1. Launch the NEARcom app and read the current settings by pressing the Read button at the top of the screen and holding the phone near the KNET-CO2 (refer to *Inspecting the KNET-CO2 Settings* in the Configuration section of this manual).
   No setting changes can be made until this step is complete.
2. Touch *Baud Rate* and set this parameter to the value used by the rest of the network (9600, 19200, 38400, 76800, or 115200).
3. Set the *Communication Mode* parameter to BACnet: the NEARcom app will display only the parameters specific to BACnet.
4. Set the *MSTP Address* to the desired value This address is the physical-layer address that identifies the KNET-CO2 being installed to the network and must be unique to the MSTP network segment.
5. Set the *Maximum Master* parameter to the desired value. It must be set to a value greater-than or equal to the highest MSTP address that will be used on this MSTP segment (trunk) to which the device is connected.
   Caution: setting max master too low may result in nodes which are unable to communicate. **If in doubt max master should be set to 127.**
6. Set the *Device Instance* to a unique value <u>for the entire BACnet network</u> (value ranges from 0 to 4194302).
7. Select and enter the desired text for *Device Name*, *Device Location*, and *Device Description* parameters. These parameters can be left empty or contain up to 50 characters.
8. Select desired setting for *Relay Control Method* (Remote or Setpoint). If using Setpoint, enter a value the for *CO_2 Alarm Setpoint* parameter (refer to Table 3).
9. Transfer the new settings to the KNET-CO2 by pressing the Write button at the top of the screen, then hold the phone near the KNET-CO2 until the setting are completely transferred. Refer to *Configuring the KNET-CO2 Settings* section in this manual for more details.

SETTINGS ARE NOT TRANSFERRED TO THE KNET-CO2 UNTIL THIS STEP IS COMPLETED AND A SUCCESS DIALOG IS SHOWN.

Example configuration – Modbus

For this example, the KNET-CO2 is being configured while it is unpowered (prior to installation). The process is the same if the KNET-CO2 is powered; however, the installer should ensure the Modbus Address is unique before the KNET-CO2 is attached to an existing network.

1. Launch the NEARcom app and read the current settings by pressing the *Read* button at the top of the screen and holding the phone near the KNET-CO2 (refer to *Inspecting the KNET-CO2 Settings* in the Configuration section of this manual).
   No setting changes can be made until this step is complete.
2. Touch *Baud Rate* and set this parameter the value used by the rest of the network (9600, 19200, 38400, 76800, or 115200).
3. Set the *Communication Mode* parameter to Modbus: this will cause all Modbus specific parameters to be shown and all of the BACnet specific parameters are hidden.
4. Select the *Modbus Mode* that is being used by the rest of the network (RTU or ASCII).
5. Set the *Modbus Address* of the device being installed (1 through 247). This address is the physical layer address and **must be unique** to prevent multiple devices from attempting to respond to queries.
6. Select the *Modbus Parity* setting that the rest of the network is using (Even, Odd, or None).
7. Select desired setting for *Relay Control Method* (Remote or Setpoint). If using Setpoint, enter a value the for *CO_2 Alarm Setpoint* parameter (refer to Table 3).
8. Transfer the new settings to the KNET-CO2 by pressing the Write button at the top of the screen, then hold the phone near KNET-CO2 until the setting are completely transferred. Refer to *Configuring the KNET-CO2 Settings* section in this manual for more details.

   NOTE: Settings are NOT changed within the KNET-CO2 until this step 8 is complete. If desired, the new settings can be verified directly after they have been transferred to the KNET-CO2 by following steps outlined in the *Inspecting the KNET-CO2 Settings* section of the manual.

Operation

Relay

The relay can be controlled by two different mechanisms, setpoint control based on the CO_2 reading or network control (default).

When the relay is driven based on the setpoint it will be inactive as long as the CO_2 concentration is below the setpoint threshold + the hysteresis value (10 ppm). Once active the relay will not transition to the inactive state until the CO_2 concentration of the space falls below the setpoint threshold minus the hysteresis value.

Under network control the relay state is irrevocably commanded by the network and is not responsive to local CO_2 concentration (unless commanded to be so by the network).

The operating mode of the relay is determined solely by the network. The mechanism of network relay control varies based on which communication protocol is being used; if BACnet is enabled the device controls the relay based on the binary output object using a priority array, if Modbus is enabled then the relay is driven based on the 'Relay state' register.

CO_2 Sensor

There is a 10s delay at startup before readings are available, during this time the CO_2 will read 0 ppm. If setpoint control is enabled the relay will be inactive during startup to allow time for the CO_2 sensor to initialize.

The CO_2 reading is updated once every second.

Sensor Supervision

The proper operation of the sensor is continually monitored by its internal supervision functionality. The following network properties are set should a sensor failure be detected.

BACnet	Reliability property of Analog Input 1: unreliable other
	Status_Flags property of Analog Input 1: 'fault bit' is SET
Modbus	Register 4001 (CO_2 Status) returns Status Code 7

Table 4: Out of Service notification. The unit is declared out of service during calibration or if sensor fails.

BACnet

A complete list of the objects available on the KNET-CO2 is available starting on page 18.

The device will initiate a single *i-am* after power-up to enable faster device discovery but otherwise will not initiate any network traffic (except token passing and polling for masters) without being queried.

If supporting hardware, such as the relay, is not present then the *Reliability* property for the corresponding object will indicate this.

None of the objects support event state reporting and *Event State* for all objects will always read Normal (0).

Modbus

The KNET-CO2 uses either Modbus RTU or ASCII and supports even, odd, and no parity. The default settings are Modbus RTU with even parity.

Each frame is formatted based on settings as shown below in Table 5.

Mode Setting	Parity Setting	Start Bits	Data Bits	Parity Bits	Stop Bits
RTU	Even	1	8	1	1
	Odd	1	8	1	1
	None	1	8	0	2
ASCII	Even	1	7	1	1
	Odd	1	7	1	1
	None	1	7	0	2

Table 5: Modbus Data Formatting

The register table is available on Table 6 on page 22. All registers are modeled as holding registers. If a register is listed as read-only then any attempts to write to the register will receive an error response.

Registers can be read with function code 3 (read holding register) and written with function code 6 (write single register). Attempts to write to a read-only register will receive an error response with exception code 4.

The mode, parity, device address, and baud rate are set using the NEARcom configuration application.

Calibration

During calibration the KNET-CO2 Analog Input object's reliability will be set as shown in Table 4. During the calibration, the relay will be in an inactive state even if the CO_2 is above the setpoint.

Calibration requires a calibration kit with calibration grade 2000 ppm CO_2, balance air or nitrogen gas, available from KELE as part number KCAL-2000. Assemble its gas delivery components as shown in Figure 8.

Figure 9 shows the location of the KNET-CO2's calibration port. Insert the ¼ inch OD gas delivery tube through it and over the calibration nipple of the sensor inside.

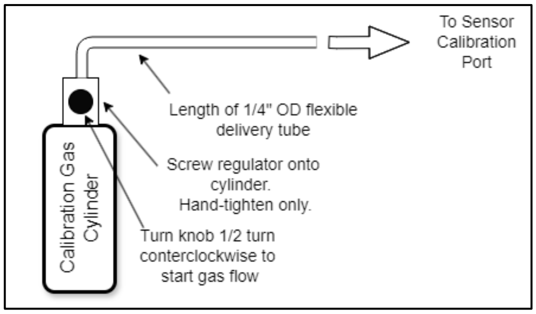

Figure 8: Calibration Gas Delivery Apparatus:

No changes are made until the calibration is confirmed during step 5; if an error is made during the process, remove and reconnect the KNET-CO2's power to abort the calibration.

Calibration Procedure

1. Temporarily remove the dust cover from the calibration gas port on the bottom of the enclosure cover.
2. Pass the 1/4" OD calibration gas tube into the 'Calibration Gas Port' and slide onto the fitting inside. Enable calibration gas flow by turning the regulator knob a half-turn counter-clockwise (see Figure 8).
3. Allow calibration gas to flow for one minute, then use a 1/16" Allen wrench (or equivalent) to depress the "CO2 Calibration Activator" switch for 5 seconds until the LED blinks yellow.
4. After a few minutes the LED will blink green. The calibration process is completed.
5. Remove calibration gas tube from case and ensure that the 'hiss' of flowing gas can still be heard.
   If gas flow is NOT DETECTED the KNET-CO2 has very likely been mis-calibrated. Briefly disconnect the unit's power to abort the calibration. Replace the calibration gas cylinder and repeat the process starting at step 2.
6. If gas is still flowing, press and hold the calibration button to accept and save the calibration. The LED will turn solid green, indicating that calibration is complete.
   If the calibration process is not confirmed within 5 minutes after the LED turns green in step 4, the unit will abandon the calibration and return to normal operation with the calibration unchanged.
7. Disable gas flow by turning the regulator knob fully clockwise, and remove gas tubing from the calibration port.
8. Replace the dust cover on the gas calibration port.

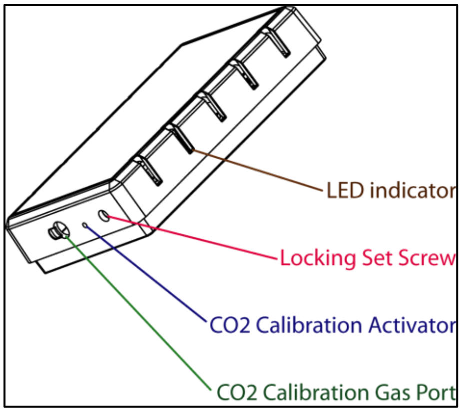

Figure 9:Calibration landmarks

Disclaimers

Life Safety

This KNET-CO2 is not designed, certified, sold or authorized for use in applications where failure of this device could be reasonably expected to result in personal injury or death.

Warranty

Kele warrants to Buyer that for the duration stated in Table 1 (on page 6) from the date of shipment of Products to the Buyer that Products will substantially conform to the product specifications agreed to by Kele. This warranty is not transferable.

This warranty does not cover:

- Defects due to misuse, abuse, or improper or inadequate care, service or repair of Products;
- Defects due to modification of Products, or due to their alteration or repair by anyone other than Kele;
- Problems that arise from lack of compatibility between Kele Products and other components used with those Products or the design of the product into which Products are incorporated. Buyer is solely responsible for determining whether Products are appropriate for Buyer's purpose, and for ensuring that any product into which Products are incorporated, other components used with Kele's Products, and the purposes for which Kele's Products are used are appropriate and compatible with those Products.

Unless Kele agrees otherwise, to obtain service under this warranty, Buyer must pack any nonconforming Product carefully, and ship it, postpaid or freight prepaid, to Kele, Inc. at 3300 Brother Boulevard Memphis, TN 38133 before the expiration of the warranty period shown in Table 1. Buyer must include a brief description of the nonconformity. Any actions for breach of this warranty must be brought within one year of the expiration of this warranty.

If Kele determines that a returned Product does not conform to this warranty it will, at its sole discretion, either repair or replace that Product, and will ship the Product back to Buyer free of charge. At Kele's option, Kele may choose to refund to Buyer the purchase price for a nonconforming Product instead of repairing or replacing it.

Appendix 1: BACnet objects and default values

Device Object

Property	Default	Access permissions
Object_Identifier	(device, 283000)	Read / Write
Object_Name	KNET-CO2	Read / Write
Object_Type	8 : Object Device	Read
System_Status	0 : Operational	Read
Vendor_Name	Kele, Inc.	Read
Vendor_Identifier	283	Read
Model_Name	KNET-CO2	Read
Firmware_Revision	v2.0.2	Read
Application_Software_Version	v2.0.2	Read
Location	"": empty string	Read / Write
Description	CO2 sensor	Read / Write
Protocol_Version	1	Read
Protocol_Revision	14	Read
Protocol_Services_Supported	ReadProperty, WriteProperty, DeviceCommunicationControl, Who-Has, Who-Is	Read
Protocol_Object_Types_Supported	analog-input, analog-value, binary-output, binary-value, device	Read
Object_List	{(device, 283000), (analog-input, 1), (binary-output, 1), (analog-value, 1), (binary-value, 1)}	Read
Max_APDU_Length_Accepted	480	Read
Segmentation_Supported	3 : None	Read
APDU_Timeout	10000	Read
Number_Of_APDU_Retries	0	Read
Max_Master	127	Read / Write
Max_Info_Frames	1	Read
Device_Address_Binding	{}	Read

Property	Default	Access permissions
Database_Revision	1	Read
Property_List	{system-status, vendor-name, vendor-identifier, model-name, firmware-revision, application-software-version, protocol-version, protocol-revision, protocol-services-supported, protocol-object-types-supported, object-list, max-apdu-length-accepted, segmentation-supported, apdu-timeout, number-of-apdu-retries, max-master, max-info-frames, location, description, device-address-binding, database-revision}	Read

CO2 - Analog Input Object 1

Property	Default	Access permissions
Object_Identifier	(analog-input, 1)	Read
Object_Name	Carbon Dioxide	Read
Object_Type	0 : Object Analog Input	Read
Present_Value	Current value from sensor	Write (only when Out_Of_Service is True) / Read
Status_Flags	{F,F,F,F}	Read
Event_State	0 : Normal	Read
Reliability	0 : No Fault Detected	Read
Out_Of_Service	False	Write / Read
Units	96 : Parts Per Million	Read
Property_List	{present-value, status-flags, event-state, reliability, out-of-service, units}	Read

Relay – Binary Output Object 1

Property	Default	Access permissions
Object_Identifier	(binary-output, 1)	Read
Object_Name	Relay	Read
Object_Type	4 : Object Binary Output	Read
Present_Value	False	Read / Write
Status_Flags	{F,F,F,F}	Read
Event_State	0 : Normal	Read
Reliability	0 : No Fault Detected	Read
Out_Of_Service	False	Read / Write
Polarity	0 : Normal	Read
Inactive_Text	Inactive	Read
Active_Text	Active	Read
Priority_Array	{Null, Null, Null, Null, Null, Null, Null, Null, Null, Null, Null, Null, Null, Null, Null, Null}	Read
Relinquish_Default	False	Read / Write
Property_List	{present-value, status-flags, event-state, reliability, out-of-service, polarity, inactive-text, active-text, priority-array, relinquish-default}	Read

Relay Setpoint - Analog Value Object 1

Property	Default	Access permissions
Object_Identifier	(analog-value, 1)	Read
Object_Name	Relay Setpoint	Read
Object_Type	4 : Object Binary Output	Read
Present_Value	1000	Read / Write
Status_Flags	{F,F,F,F}	Read
Event_State	0 : Normal	Read
Out_Of_Service	False	Read
Units	96 : Parts Per Million	Read
Property_List	{present-value, status-flags, event-state, out-of-service, units}	Read

Enable Local Relay Control - Binary Value Object 1

Property	Default	Access permissions
Object_Identifier	(binary-value, 1)	Read
Object_Name	Enable Local Relay Control	Read
Object_Type	5 : Object Binary Value	Read
Present_Value	inactive	Read / Write
Status_Flags	{F,F,F,F}	Read
Event_State	0 : Normal	Read
Out_Of_Service	False	Read
Inactive_Text	BACnet relay control based on the relay present value (Binary Output 1)	Read
Active_Text	Local relay control based on the setpoint present value (Analog Value 1)	Read
Property_List	{present-value, status-flags, event-state, out-of-service, inactive-text, active-text}	Read

Appendix 2: Modbus registers

Register	Name	Type	Units	Access Permissions
4001	CO_2 Status	uint16	See table below	Read
4002	CO_2 Reading	uint16	ppm	Read
4003	Enable relay setpoint control	Bool	enable=1 / disable=0	Read / Write
4004	Relay state	Bool	on=1 / off=0	Read / Write
4005	Relay setpoint	uint16	ppm	Read / Write

Table 6: Modbus Registers. The leading '4' is by convention to indicate holding register and is not sent to the device.

Status code	Description
0	Normal operation
1	No sensor present
6	No relay present
7	Sensor fault (during normal operation) or calibration ongoing (during calibration process)
12	Internal communication error

Table 7. Possible values for Modbus CO_2 status register (register 4001).

Appendix 3: 3rd Party Software Components & Licenses

The following components are used in the software of this device.

FreeModbus - https://www.embedded-experts.at/en/freemodbus/
Licensed under BSD 3-Clause license, text available at https://github.com/cwalter-at/freemodbus/blob/master/bsd.txt

FreeRTOS - https://www.freertos.org/
Licensed under MIT license, text available at https://www.freertos.org/a00114.html

JSMN - https://zserge.com/jsmn/
Licensed under MIT license, text available at https://github.com/zserge/jsmn/blob/master/LICENSE

STM HAL - https://github.com/STMicroelectronics/stm32g0xx_hal_driver
Licensed under BSD 3-Clause license, text available at https://github.com/STMicroelectronics/stm32g0xx_hal_driver/blob/master/License.md

REVISION HISTORY

Date	Comments
12/16/2024	Preliminary release as 90-0018-0a