M380 Networked CO_2 Sensor/Transmitter with Relay

User's Manual

Digital Control Systems, Inc.
6475 SW Fallbrook Pl.
Beaverton, OR 97008 • USA
www.dcs-inc.net • 503/246-8110

Table of Contents

Feature Overview

The M380 is a network-capable CO_2 sensor/transmitter with a single relay that can be set to use either local concentration-based or network-controlled actuation. The M380 can communicate using BACnet MS/TP, Modbus RTU, or Modbus ASCII, all using an RS-485 interface. The M380 is equipped with a dual beam CO_2 sensor for long-term accuracy without the need for frequent re-calibration. Configuration of settings is accomplished using the DCS NEARcom app with an NFC-capable smartphone for easy 'fill in the blanks' network setup.

CO_2 Sensor

The M380 uses a self-compensating 'dual beam', NDIR (NonDispersive InfraRed) CO_2 detection system which uses 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 accuracy, single beam systems need 'self-calibration' algorithms that can be wildly inaccurate in changing building occupancy profiles. The M380 can be used in any building occupancy profile with no compromise in long-term accuracy.

Relay

The M380 has a dry-contact, 2-Amp capable 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 the 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-neutral 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, although bridges are available that can translate messages between different transport layers.

The M380 supports only BACnet/MSTP.

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. Servers will not initiate communication unless they are directly addressed.

Modbus implements 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 M380 communicates only via RS-485.

Network Topology

The M380 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 5. Only the units at the ends of the chain have a terminating resistor connected between the two data lines.

NEARcom

NEARcom is a free app for Android and iOS phones equipped with near-field communication (NFC). NEARcom creates a virtual front panel for the M380 on a 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 M380 to read the device's current settings. After reading the M380, 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 M380 and the new settings are transferred back to the device.

Changes to the M380 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 M380's dual-beam CO_2 sensor does not need frequent calibration, it does support a single-point calibration using 2000 ppm CO_2 (balance air or nitrogen) calibration gas. A calibration kit is available from your HVAC instrumentation supplier or directly from Digital Control Systems. The calibration kit contains a compressed calibration gas cylinder (with pressure above 100 psi), a pressure regulator that fits onto the cylinder, and 1/4-inch OD plastic tubing that is connected to the calibration port on the M380 (refer to Figure 2 for calibration port location).

For accurate calibration, it is essential to keep a low flow rate of the calibration gas into the sensor during the single-point calibration process: a flow rate of 100 to 120 ml/min (milliliters/minute) is ideal. Significantly higher flow rates risk bursting the sensor's diffusion port filter membrane. Adjustments to the pressure regulator should be made to create the required low-pressure, weak-flow gas stream. Refer to the *Calibration Sequence* section included in this document for more details.

Specifications

Parameter	Value
Communication Protocols	BACnet MS/TP, Modbus RTU, Modbus ASCII
Supported Baud Rates	9600, 19200, 38400, 76800, 115200
Sensor Operating Principle	Dual-beam, non-dispersive infrared (NDIR)
Gas Sampling Method	Diffusion through sub-micron particle filter
Measurement Range	0-2000ppm (0-5000 ppm optional)
Repeatability	± 20 ppm CO2
Measurement Accuracy	± 30 ppm ± 2% of reading
Calibration	One point: single gas calibration
Recommended Calibration Interval	5 years
Warm-up Time	Less than 1 Minute
Power Requirements	15 - 40 VDC or 18 - 28 VAC RMS
Power Consumption	Less than 3 Watts
Operating Temperature Range	0 - 50° Celsius
Operating Humidity Range	5 - 95% 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, 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: M380 Specifications.

Installation

Mechanical

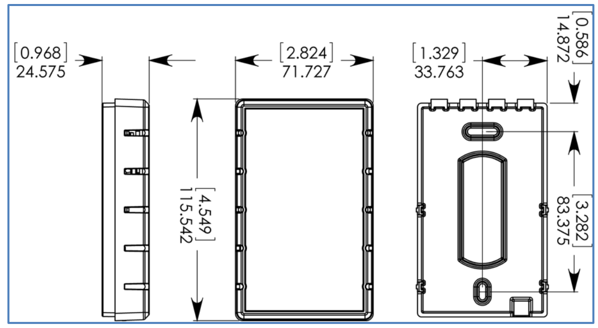


Figure 1: Case Dimensions (mm &[in]).

The M380 conveniently mounts onto a standard single-gang electrical box, with wiring entering the enclosure through the access opening in its base (refer to Figure 2). The same mounting holes can be used to affix the M380 onto a flat vertical surface with appropriate fasteners.

The unit is usually mounted vertically in an electrical box; however, it will function with slightly degraded accuracy in any orientation.

Wiring

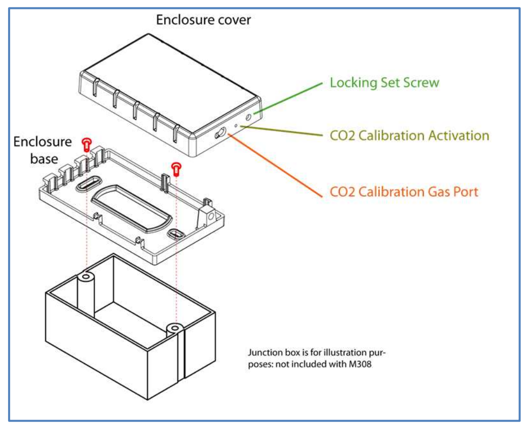


Figure 2: Attaching to single-gang electrical box.

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 connectors are removable for easier wire landing, and keyed so that they can only be inserted into the socket in the correct orientation.

Align the slots in the top of the enclosure cover with the tabs on the enclosure base and snap it closed. Back out the set screw (located on the bottom of the cover and shown in Figure 2) to secure the enclosure cover using a 3/32" Allen wrench.

Power

The M380 uses a full bridge rectifier allowing the power supply to be connected without concern for polarity. Refer to the *Power Requirements* in Table 1 for further information.

Relay

The single-pole double-throw (SPDT) relay connection terminals are shown in Figure 3. 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 terminal and the normally closed terminal will not be connected.

Network Connection

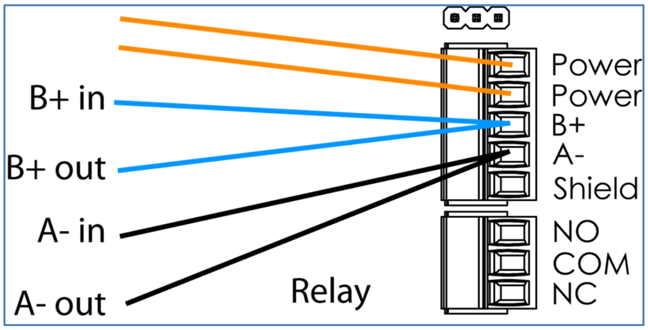


Figure 3: Wiring diagram showing connections.

The network (BACnet or Modbus) data lines should be connected in a daisy chain configuration with no stubs or branches as shown in Figure 5. The network data interconnection is a twisted-pair of two wires (sometimes shielded) which are not interchangeable and must not be confused with each other during installation.

In most installations there will be both incoming and outgoing data pairs which need to be connected. **It is critical that both A- conductors (one each from the incoming and outgoing connection) be connected to the A- terminal, and both B+ conductors to the B+ terminal.**

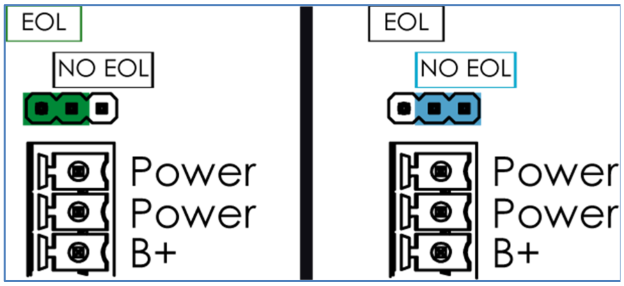
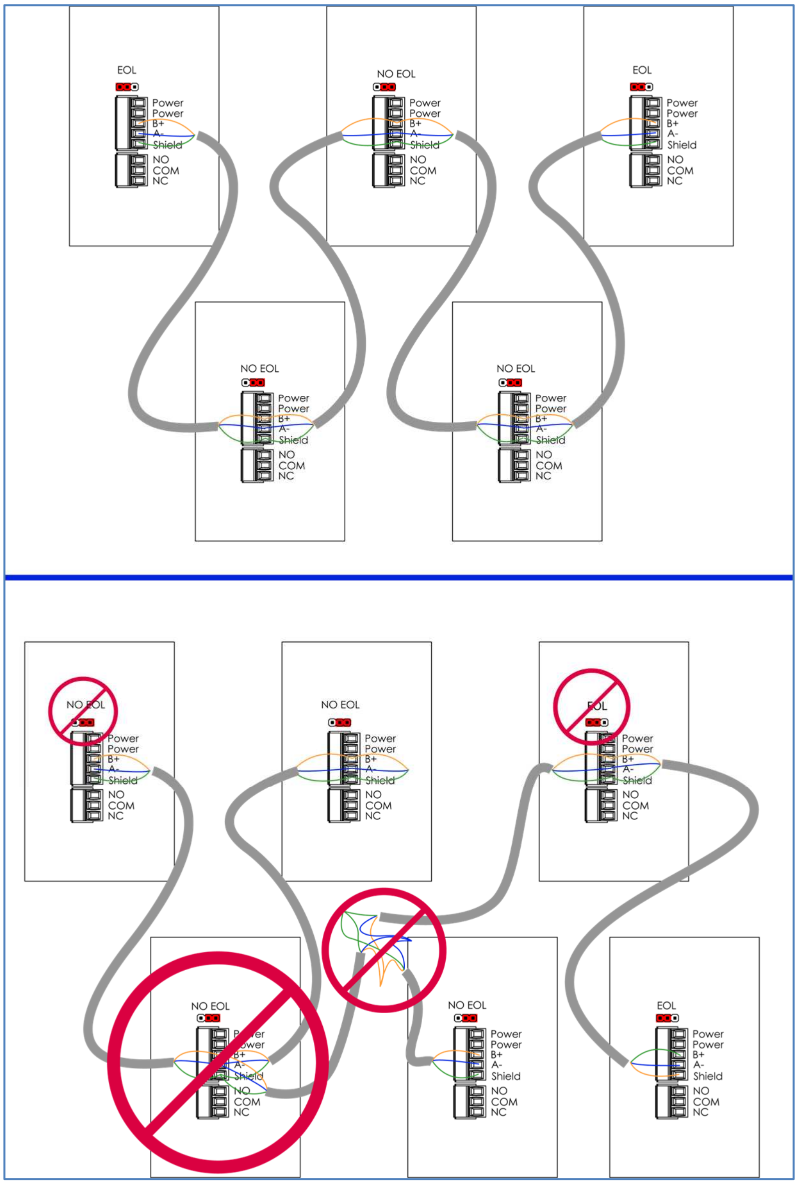


Figure 4: Data line termination jumper.
LEFT - EOL termination enabled.
RIGHT - EOL termination disabled.

If the unit being installed is the first or last unit on the chain (i.e. there are only single A- & B+ wires) the end-of-line resistor should be enabled by setting the EOL jumper (see Figure 4) to the EOL position with the shorting block on the left. **Only the first and last devices in the daisy chain should have EOL termination enabled.**

The shield connection on the terminal is provided for convenience in splicing cable shielding together. It is not electrically connected to the M380 and using the connector to couple the shields is optional. The shield for the entire trunk should be tied to ground only at a single point, typically the BAS.



<u>Figure 5</u>: 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).

Configuration

Because of the relatively complex setup required to configure a networked sensor, the configuration is done through a graphical user interface (GUI) on either an Apple or Android smart phone with Near Field Communication (NFC). NFC is a popular, short-range wireless technology that allows a smart phone to communicate with an external device. Most modern smart phones are equipped with NFC as this is commonly used to allow a phone to act as a transit pass, or for wireless payment.

The NEARcom app uses NFC to quickly and intuitively configure the M380; this app is freely available from either the Apple App-Store or Google Play.

App Store

https://apps.apple.com/app/id1595984749

Google Play

https://play.google.com/store/apps/details?id=net.dcsinc.bacnetconfiguration

NEARcom

The free NEARcom app is used to review and configure the M380 settings by providing a short-range link between a smart phone and the M380. The M380 settings are transferred to the phone by holding the phone up to the front cover (with the middle-back of the phone near the area indicated in Figure 6). After the settings have been transferred, the phone can be taken away so that the current settings can be inspected and altered from a comfortable position. After changes are made, the phone is placed near the M380 antenna (shown in Figure 6) again to transfer the new settings to the M380.

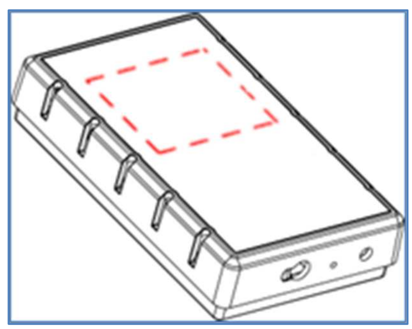


Figure 6: Approximate location of the M380's NFC antenna.

The configuration settings can be inspected and changed while the M380 is unpowered (prior to installation), or while it is powered and running normally. If the M380 is powered when changes are made there may be a short delay (less than 10s) before the changes are applied.

Refer to the following section for details on using NEARcom to inspect and adjust the M380's settings.

Inspecting the M380 Settings

This process can be done with M380 powered or unpowered (prior to installation). Before proceeding, download and install the NEARcom app from the Apple App-Store or from the Google Play Store.

Figure 7: NEARcom App Icon.

1. If an Android phone is being used, ensure NFC turned on: refer to the phone's manual for more information.
2. Locate and launch the NEARcom app (refer to Figure 7): 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 M380.
4. Hold the middle-back of the phone near the area indicated in Figure 6. After the transfer is complete, the phone can be moved away from the M380, and the app will display all of the M380's current settings.

Configuring the M380 Settings

1. Follow the steps outlined in *Inspecting the M380 Settings* section above: no setting configurations are allowed until the current device settings have been retrieved.
2. 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 M380. When settings are changed, their fields will be highlighted to indicate they will be updated during the next *Write* transfer.
3. 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 M380 to transferring the new settings.

   NOTE: the "Write" button will be grayed out and inactive until a change to the settings have been made.

4. Place the middle-back of the phone over the area indicated in Figure 6 and hold it in this location until the prompt is removed.

   NOTE: moving the phone away from the M380 too early will abort transferring the new setting and an error message will be displayed. If this occurs, dismissed the error message, place the phone over the M380 and hold it place until the transfer is complete.

Configuration Procedure

Network Type	Parameter Name	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 the network and less than or equal to the value of *MSTP Maximum Master*.
	Maximum Master	1 to 127	Must greater than or equal to *MSTP Address*.
	Device Instance	0 to 4194302	Must be unique in the network.
	Device Name	Limited to 50 characters	Text field for user input of a device name.
	Device Location	Limited to 50 characters	Text field for user input describing the device's location.
	Device Description	Limited to 50 characters	Text field for user input of description.
Modbus	Modbus Mode	RTU, ASCII	Transmission mode of message in network.
	Modbus Address	1 to 247	Must be unique on the subnet.
	Modbus Parity	Even, Odd, None	Communication parity bit.

Table 2: Configuration parameters for BACnet and Modbus network.

Device Configuration Parameters	Value	Description
Relay Control Method	Remote or Setpoint	**Remote**: the network has control of the M380 relay actuation. **Setpoint**: the M380 has control of relay actuation based on the value of *CO_2 Alarm Setpoint.*
CO_2 Alarm Setpoint (ppm)	0 to 5000	The M380 relay will actuate when the CO_2 concentration rises above this setting (refer to *Relay* in the *Operation* section for more details).

Table 3: Device configuration parameters.

Before beginning the configuration process:

1. Determine and record the parameters needed for your installation: a list of the parameters for a BACnet or Modbus network is shown in Table 2.
2. Determine out the M380 relay will be controlled (refer to Table 3 for more information).

> NOTE: All M380 BACnet parameters for any previously configured units can easily be determined; refer to *Inspecting the M380 Settings* in the *Configuration* section of this manual.

Example configuration – BACnet

For this example, the M380 is being configured while it is unpowered (prior to installation). The process is the same if the M380 is powered; however, the installer should ensure the *MSTP Address* and *Device Instance* are unique before the M380 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 M380 (refer to *Inspecting the M380 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 *BACnet*: this will cause all BACnet specific parameters to be shown and all of the unused Modbus parameters are hidden.
4. Set the ***MSTP Address*** to the desired value: this address is the physical-layer address that identifies the M380 being installed to the network and must be unique to the MSTP network segment.
5. Set the ***Maximum Master*** parameter to the desired value; this value must be greater-than or equal-to the *MSTP Address* setting. The value of Maximum Master is the highest MSTP address to which the M380 will attempt to pass the MSTP token. This value must be unique to the MSTP subnet that the device will use.
6. Set the ***Device Instance*** to a unique value for the entire BACnet internetwork (value ranges from 0 to 4194302).
7. Select and enter desired text for the ***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 M380 by pressing the *Write* button at the top of the screen, then hold the phone near M380 until the setting are completely transferred. Refer to *Configuring the M380 Settings* section in this manual for more details.

> NOTE: **Settings are NOT changed within the M380 until this step is complete**. If desired, the new settings can be verified directly after they have been transferred to the M380 by following steps outlined in the *Inspecting the M380 Settings* section of the manual.

Example configuration – Modbus

For this example, the M380 is being configured while it is unpowered (prior to installation). The process is the same if the M380 is powered; however, the installer should ensure the *Modbus Address* is unique before the M380 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 M380 (refer to *Inspecting the M380 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*** (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 ***CO2 Alarm Setpoint*** parameter (refer to Table 3).
8. Transfer the new settings to the M380 by pressing the *Write* button at the top of the screen, then hold the phone near M380 until the setting are completely transferred. Refer to *Configuring the M380 Settings* section in this manual for more details.

> NOTE: **Settings are NOT changed within the M380 until this step is complete**. If desired, the new settings can be verified directly after they have been transferred to the M380 by following steps outlined in the *Inspecting the M380 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 until the CO_2 concentration rises 10 ppm above the *Relay Setpoint*. Once the relay is active, it will not transition to inactive until the CO_2 concentration falls 10 ppm below the *Relay Setpoint*.

Under network control the relay state is determined solely by the network and is not responsive to local CO_2 concentration. The mechanism of network relay control varies based on which communication protocol is being used; if BACnet is enabled, the M380 controls the relay based on the binary output object (BO1) using a priority array. If Modbus is enabled, the relay is driven based on the "Relay state" register (4004).

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. After this startup delay, the CO_2 reading is updated once ever second.

BACnet

A complete list of the objects available on the M380 is available starting in *Appendix 1* of this manual.

The M380 will initiate a single *i-am* message after power-up to enable faster network discovery, but otherwise will not initiate any network traffic (except MSTP level token passing and polling for masters) without being queried.

If optional hardware, such as the relay, is absent then the *Reliability* propery for the corresponding object will indicate this.

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

Modbus

The M380 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 4.

The Modbus register table is available in *Appendix 2*, Table 5 of this manual. 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 configuration application.

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 4: Modbus Data Formatting

Calibration Sequence

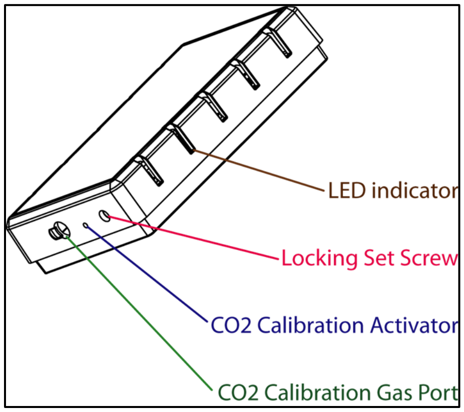


Figure 8: Calibration Landmarks

During calibration the BACnet CO_2 Analog Input object's reliability will be set to 'no output' for the duration of the calibration process, upon completion of the calibration it will revert to 'no fault'. 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 DCS.

Refer to Figure 8 while performing the calibration sequence below. If an error is made during the process, remove and reconnect power and restart if desired.

No changes are made until the calibration is confirmed during step 5 and any changes are reversible if the calibration process is repeated.

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 of 100 to 120 ml/min (significantly higher flow rates risk bursting the sensor's diffusion port filter membrane).
3. Allow calibration gas to flow for one minute, then use a 1/16" Allen wrench (or equivalent) to depress the *CO_2 Calibration Activator* switch for 5 seconds until the LED blinks yellow.
4. After 5 minutes the LED will blink green: the calibration process is completed, but must be confirmed before it applied.
5. 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 the unit will abandon the calibration and return to normal operation.
6. Remove calibration gas tube from case and ensure that gas is still flowing.

   Note: **If gas is not flowing**, the M380 has been mis-calibrated: replace the calibration gas with a new cylinder and repeat the process starting at step 2.

7. Disable gas flow and remove gas tubing from the calibration port.
8. Replace the dust cover on the gas calibration port.

Disclaimers

Life Safety

This M380 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

Digital Control Systems warrants to Buyer that for the duration stated in Table 1 from the date of shipment of Products to the Buyer that Products will substantially conform to the product specifications agreed to by Digital Control Systems. 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 Digital Control Systems;

Problems that arise from lack of compatibility between Digital Control Systems' 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 Digital Control Systems' Products, and the purposes for which Digital Control Systems' Products are used are appropriate and compatible with those Products.

Unless Digital Control Systems agrees otherwise, to obtain service under this warranty, Buyer must pack any nonconforming Product carefully, and ship it, postpaid or freight prepaid, to Digital Control Systems, Inc. at 6475 SW Fallbrook Pl, Beaverton, OR 97008 before the expiration of the warranty period. 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 Digital Control Systems determines that a returned Product does not conform to this warranty it will, at Digital Control Systems' sole discretion, either repair or replace that Product, and will ship the Product back to Buyer free of charge. At Digital Control Systems' option, Digital Control Systems 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, 483000)	Read / Write
Object_Name	M380-CO2	Read / Write
Object_Type	8 : Object Device	Read
System_Status	0 : Operational	Read
Vendor_Name	Digital Control Systems	Read
Vendor_Identifier	483	Read
Model_Name	M380-CO2	Read
Firmware_Revision	d99b2ea	Read
Application_Software_Version	1.0.3 (iOS) / 1.0.1 (Android)	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, 483000), (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

CO_2 - 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	CO2 Status	uint16	See table below	Read
4002	CO2 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 5: 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	Calibration ongoing
12	Internal communication error

Table 6. Possible values for Modbus CO2 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	Name	Summary of Changes
05 August 2021	RAJ	Table formatting, Fig 1 & 3 changed.
09 August 2021	RAJ	Minor text changes to connections section.
16 August 2021	RAJ	Update images for figs. 1 & 4
20 August 2021	RAJ	
01 September 2021	MMM	Misc cosmetic and formatting changes. Added cal kit language.
15 September 2021	DC & MM	Added NEARcom app overall operating introduction. Some format and pagination changes.
26 September 2022	MM	Cosmetic changes for beta release.
09 March 2023	DC	Changes to NEARcom and Configuration Procedure sections so they are accurate with new NEARcom app. General cosmetic and formatting changes.