EGM-5

Portable CO$_2$ Gas Analyzer

Operation Manual

Version 1.04

Contents

Welcome

Thank you very much for purchasing our **EGM-5 CO₂ Gas Analyzer**. We greatly appreciate your business and we look forward to working with you and your team for many years to come.

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For applications where failure of this equipment to function correctly would lead to consequential damage, the equipment must be checked for correct operation and calibration at intervals appropriate to the circumstances. The PP Systems' equipment warranty is limited to replacement of defective components, and does not cover injury to persons or property or other consequential damage.

This manual is provided to help you install and operate the equipment. Every effort has been made to ensure that the information it contains is accurate and complete. PP Systems does not accept any liability for losses or damages resulting from the use of this information.

It is the operator's responsibility to review this information prior to installation and operation of the equipment. Otherwise, damage may be caused which is not covered under our normal warranty policy.

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User Registration

It is very important that ALL new customers register themselves with us to ensure that our user's list is kept up-to-date. If you are a PP Systems' user, please go to www.ppsystems.com and click on Customer Registration in the upper left hand corner.

Only **REGISTERED** users will be allowed access to the protected "Users" section of our web site. This section will contain important product information including hardware/software updates, application notes, newsletters, etc.

Thank you in advance for your cooperation.

Service & Warranty

PP Systems' equipment warranty is limited to replacement of defective components, and does not cover injury to persons or property or other consequential damage.

The equipment is covered under warranty for one complete year, parts and labor included. This, of course, is provided that the equipment is properly installed, operated and maintained in accordance with written instructions (i.e. Operator's Guide).

The warranty excludes all defects in equipment caused by incorrect installation, operation or maintenance, misuse, alteration, and/or accident.

If for some reason, a fault is covered under warranty, it is the responsibility of the customer to return the goods to PP Systems or an authorized agent for repair or replacement of the defective part(s).

Prior to returning equipment to PP Systems for service, you must first get in contact with our Service Manager (service@ppsystems.com) to request a case number for reference and tracking purposes.

Contact Information

PP Systems, Inc.
110 Haverhill Rd, Suite 301
Amesbury, MA 01913 USA
Tel: 978-834-0505 Fax: 978-834-0545

Sales: sales@ppsystems.com
Support: support@ppsystems.com
Service: service@ppsystems.com
URL: www.ppsystems.com

Unpacking and Storage of Your Equipment

Unpacking

It is extremely important that you check the contents of your equipment immediately upon receipt to ensure that your order is complete and that it has arrived safely. Please refer to the packing list to show all items that are included with your order. **DO NOT DISCARD ANY OF THE PACKAGING MATERIAL UNTIL ALL OF THE ITEMS LISTED ARE ACCOUNTED FOR. WE RECOMMEND THAT YOU RETAIN THE ORIGINAL PACKING FOR FUTURE USE.** If you suspect that any of the items listed on the packing list are not included or damaged, you must contact PP Systems or your authorized distributor immediately.

Powering up the EGM-5 for the First Time

When you receive your new EGM-5 from PP Systems you will need to first connect it up to the external power supply/charger prior to powering up the instrument. To avoid accidental power up during shipment we put the instrument into "Ship Mode" (see Ship Mode on page 53). Therefore, when you are ready to begin:

1. Locate the power supply/charger and power cord inside the packing box.
2. Connect the AC power cord to the mains and the barrel connector into the EXT Power socket on the back of the EGM-5.
3. Press the ON/OFF switch to power up the instrument. The power switch should now have an illuminating blue ring indicating power is on.
4. Allow 10-15 minutes to achieve warm-up.

You are ready to go!

Data Storage

For convenience and ease it is very important to note that all EGM-5 system data is recorded and saved directly to a USB flash drive (i.e. memory stick or thumb drive). A USB flash drive is included in the spares kit (Part No. 43034-1) with every new system.

THEREFORE IT IS IMPERATIVE THAT YOU HAVE A USB FLASH DRIVE WITH YOU AT ALL TIMES IF YOU WANT TO RECORD DATA WITH YOUR EGM-5. **OTHERWISE DATA WILL HAVE TO BE RECORDED MANUALLY.**

Technical Specification

Analysis Method	Non-dispersive infrared, configured as an absolute absorptiometer with microprocessor control of linearization
CO_2 Measurement Ranges	0-1000 ppm (μmol mol^{-1}) 0-2000 ppm (μmol mol^{-1}) 0-5000 ppm (μmol mol^{-1}) 0-10000 ppm (μmol mol^{-1}) 0-20000 ppm (μmol mol^{-1}) 0-30000 ppm (μmol mol^{-1}) 0-50000 ppm (μmol mol^{-1}) 0-100000 ppm (μmol mol^{-1}) Readings are automatically corrected for temperature and pressure.
Accuracy	< 1% of span concentration over the calibrated range but limited by the accuracy of the calibration mixture.
Linearity	< 1% throughout the range
Stability	Auto-zero at regular intervals corrects for sample cell contamination, source and detector ageing and changes in electronics.
Warm-up Time	Approximately 15 minutes
Sampling Rate	10 Hz. Sample data is averaged and output every 1.0 seconds.
Sampling Pump	Integral, 5V rotary vane air sampling pump
Gas Flow Rate	100-500 cc/min (280-340 cc/min is optimal). An internal, electronic flow sensor monitors flow rate.
Terminal Block	External 10 pin terminal connector for; +5V, Ground, Analog input, Analog output, and alarm relays.
Analog Input	0-1.0V
Analog Output	0-2.5V (CO_2 range selectable)
Alarm	2 relay contacts (Alarm1 and Alarm2), Visual and Audible alarm/warnings.
Communications	USB(USB Mini-B) and Optional Wi-Fi
Air Filter	Internal hydrophobic filter is used to protect analyzer from water.
CO_2 Control	High and low user set points
Data Storage (USB)	USB Flash Drive for data storage
Display	2.7" electronic paper touch display with 264 x 176 pixel resolution
Power Switch	Illuminated On/Off power switch
Internal Battery	7.2 Volt - 8.7Ah (63Whr) Li-Ion battery providing up to 16 hours continuous operation. If external sensors/accessories are used with the EGM-5 it will reduce the operation time.
Power Requirements	12 VDC, 3.0A or AC Adapter (included) 100-240 VAC, 50-60 Hz, 1.0A
Power Consumption	Charging Battery: 30W (12V @ 2.5A) Warm up: 12W (12V @ 1.0A) Normal operation: 6W (12V @ 0.5A)
Gas Connections	2 Quick disconnect style fittings (inlet and exhaust) for use with 1/8" (.125") ID tubing
Operating Temperature	0-50 ºC, non-condensing. External filtration may be required in dirty environments.
Enclosure	Durable Cast-Urethane and aluminum, IP43 enclosure
Dimensions	215 cm W x 200 cm H 120 cm W (Enclosure only)
Weight	1.6 kg

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Summary of System Design

Overview and Theory

The EGM-5 is designed to function as a self-contained instrument for continuous measurement of CO_2 in air. Its open-path design allows for continuous, unattended air sampling, as the pump introduces fresh sample gas to the essential component, the IRGA (infrared gas analyzer).

The IRGA forms the core of gas analysis systems that measure CO_2. Non-dispersive infra-red (NDIR) refers to the transmission of a broad-band infra-red wavelength from the IRGA source lamps. A single IRGA consists of four basic components:

- Infra-red source
- Sample cell of known path length and volume
- Optical interference filter
- Infra-red detector
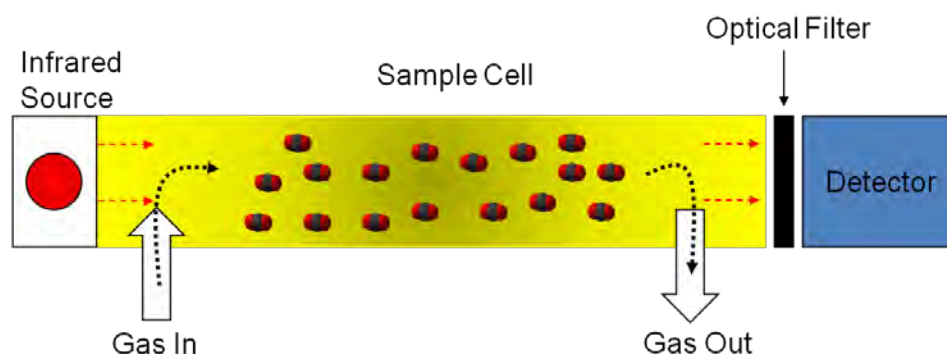
The theory itself is quite simple – light from mid-infra-red wavelengths is produced by the source and pulsed through a gold plated cell. The interference filter narrows the bandwidth of the IR source received by the detector to the signature wavelength absorbed by the target gas molecule, e.g. CO_2. The CO_2 cell employs a unique optical filter. As the sample gas fills the cell, the target gas molecule absorbs IR energy at the particular wavelength, and the reduction in IR energy reaching the detector is measured. The *higher* the target gas concentration, the *lower* the infra-red signal received at the detector, as defined by the Lambert-Beer Law of Attenuation.

CO_2 molecules have a discrete absorption band at 4.26 μm that has very little overlap with any other molecule's absorption band, so that wavelength provides good sensitivity and selectivity. The EGM-5 electronics could be considered another major component, which processes raw analog-to-digital (A/D) information from the IRGA detector, accurately translating this information into gas concentrations.

The EGM-5 detector is optimized for this CO_2 waveband (4.26 μm)
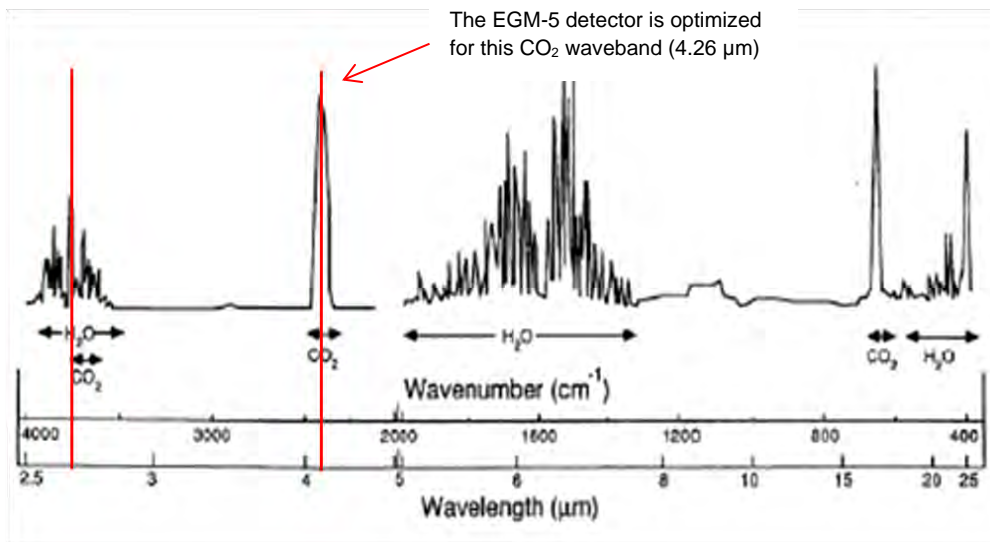
The gas sample is of course a mixture of gas molecules, and this can present problems in terms of accurate detection of concentrations of a specific gas, such carbon dioxide. This effect, *foreign gas broadening* (FGB), must be corrected to ensure accurate measurement of gas concentrations. With FGB, the CO_2 gas in the IRGA cell is somewhat diluted by the increased air volume induced by water vapor. This effect is about 0.1 μmol mol^{-1} CO_2 mb^{-1} H_2O. The presence of water vapor also causes an increase in infra-red absorption, which is detected as an apparent increase in [CO_2]. This is of a similar magnitude, but opposite to the dilution effect, and the EGM-5 automatically corrects these FGB effects.

The EGM-5 IRGAs are quite stable owing to their construction, calibration and thermal environment, but various circumstances can cause apparent changes over time. Some changes may require recalibration, although one of the strengths of the EGM-5 is that recalibration is not a routine (annual) maintenance task as a result of our innovative "Auto-Zero" function. Our Auto-Zero function corrects for nearly all changes that result in calibration drifts. It minimizes effects on span (gas sensitivity), of sample cell contamination, lamp aging, changes in detector sensitivity, amplifier gains and reference voltages. Measurements are ratios based on the Zero reading before IR absorbance is determined. From the relationship between absorbance and concentration determined in the factory for each instrument, and the current calibration factor, the sample concentration is determined.

Optional Sensors for use with EGM-5

Internal Sensors and WiFi

The O_2 and H_2O sensors are built into the EGM-5 enclosure.

O_2 Sensor

An optional electrochemical O_2 sensor can be used with the EGM-5 for measurement of oxygen in addition to CO_2.

- Range: 0-100%
- Response Time: ≤ 15 seconds at 23 ± 2 ^{o}C
- Linearity: ± 1.0% of full scale

The O_2 sensor is mounted into a manifold located inside the enclosure and is fitted in-line to sample the incoming gas stream. Recalibration should not be necessary and based on our experience with this sensor it should have a working life of approximately 4-5 years.

H_2O Sensor

An optional solid state H_2O sensor can be used with the EGM-5 for measurement of H_2O in addition to CO_2.

- Range: 0-Dewpoint (mb)
- Accuracy: < 2% RH

The humidity sensor is mounted into a manifold located inside the enclosure and is fitted in-line to sample the incoming gas stream. Readings are displayed and recorded in absolute vapor pressure (mb). Recalibration of this sensor is not necessary.

WiFi

Optional WiFi is available for use with the EGM-5. Refer to Wireless on page 96 for more information.

External Sensors/Chambers

The following sensors/chambers are external to the EGM-5 and electrical connection is made to the Probe Ports (Probe 1 and Probe 2) located on the back of the EGM-5. See Probe Port Settings on page 40 for more information for proper connection. Gas connections (if applicable) are made to the "Gas In" and "Gas Out" ports on the back of the EGM-5.

Quantum Sensor

An optional quantum sensor (Apogee Instruments) is available for use with the EGM-5 for accurate measurement of PAR (Photosynthetically Active Radiation) and it is specifically calibrated for use in sunlight conditions. The sensor housing features a fully potted, dome-shaped head, making the sensor fully weatherproof for self-cleaning. **Never use an abrasive material or cleaner on the diffuser**.

- Range: 0-3000 μmol m^{-2} s^{-1}
- Calibration Uncertainty: ± 5%
- Measurement Repeatability < 1%
- Long Term Drift: < 2% per year
- Cable Length: 5 meters

An optional leveling unit (ACS039) is also available for use with the quantum sensor. We highly recommend that you mount the sensor on a horizontal surface and that it is level for best results. To minimize azimuth error, the sensor should be mounted with the cable pointing toward true north in the northern hemisphere or true south in the southern hemisphere. Azimuth error is typically less than 1%, but is easy to minimize by proper cable orientation.

We recommend recalibration of the quantum sensor every 2 years.

TRP-3 Temperature/PAR Probe

An optional probe can be used with the EGM-5 for measurement of temperature and PAR. It consists of a rugged, aluminum housing with black foam cover. It also includes a standard tripod thread mount for use with commercially available tripods. The single gas connection for this probe is made to the "Gas In" port on the EGM-5.

Temperature Sensor (Precision Thermistor)

- Range: 0-50 $^{\circ}$C
- Accuracy: ± 0.3 $^{\circ}$C at 25 $^{\circ}$C

PAR Sensor

- Fully cosine corrected
- Range: 0-3000 μmol m^{-2} s^{-1}
- Accuracy: ± 10 μmol m^{-2} s^{-1}

Cable Length: 1.5 meters

We recommend recalibration of the PAR sensor every 2 years.

SRC-2 Soil Respiration Chamber

Our SRC-2 Soil Respiration Chamber is available for use with the EGM-5 for measurement of closed system, soil CO_2 efflux. There are two gas connections required, one to the **GAS IN** port, and the other to the **GAS OUT** port on the EGM-5. It is constructed out of rugged PVC with a convenient handle for placement on the soil surface. An aluminum ring provides a good seal on the soil surface or on collars.

- Dimensions: 150 mm (Height) x 100 mm (Diameter)
- Volume: 1171 ml
- Area: 78 cm^2
- Cable Length: 1.5 meters

It includes a temperature sensor for measurement of air temperature near the soil surface.

Temperature Sensor (Precision Thermistor)

- Range: 0-50 °C
- Accuracy: ± 0.3 °C at 25 °C

CPY-5 Canopy Assimilation Chamber

Our CPY-5 Canopy Assimilation Chamber is available for use with the EGM-5 for measurement of closed system, net canopy CO_2 flux. It is transparent and constructed out of rugged polycarbonate with an aluminum ring, which provides a good seal on the soil surface or on collars. It also includes sensors for measurement of air temperature and PAR within the chamber. There are two gas connections required, one to the **GAS IN** port and the other to the **GAS OUT** port on the EGM-5.

- Dimensions: 145 mm (Height) x 146 mm (Diameter)
- Area: 167 cm^2
- Cable Length: 1.5 meters

Temperature Sensor (Precision Thermistor)

- Range: 0-50 °C
- Accuracy: ± 0.3 °C at 25 °C

PAR Sensor

- Fully cosine corrected
- Range: 0-3000 µmol m^{-2} s^{-1}
- Accuracy: ± 10 µmol m^{-2} s^{-1}

We recommend recalibration of the PAR sensor every 2 years.

STP-2 Soil Temperature Probe

An optional soil temperature sensor can be used with the EGM-5 for measurement of soil temperature. It is commonly used with the SRC-2 Soil Respiration Chamber and CPY-5 Canopy Assimilation Chamber.

It is a rugged sensor with electronics housed in an anodized aluminum enclosure with stainless steel tip.

- Dimensions: Handle: 200 mm (Length) x 18.7 mm (Diameter)
                 Tip: 125mm Length
- Cable Length: 1.5 meters

Temperature Sensor (Precision Thermistor)

- Range: 0-50 ºC
- Accuracy: ± 0.3 ºC at 25 ºC

Soil Moisture and Soil Temperature Sensor

An optional soil moisture and soil temperature sensor (HydraProbe II - Stevens Water Monitoring Systems) is available for use with the EGM-5. It is an all-in-one, in-situ sensor that can measure both soil moisture and soil temperature.

Soil Moisture Sensor

- Range: 0-100% ((dry to fully saturated)

Soil Temperature Sensor

- Range: -10 ºC-55 ºC
- Accuracy: ± 0.3 ºC at 25 ºC

Cable Length: 5 meters

For best results the 3 prongs should be pushed all the way into the ground until the white body of the sensor is flush with the soil surface.

Recalibration of this sensor is not necessary.

System Power

The EGM-5 has an internal, rechargeable lithium ion battery pack capable of providing continuous power to the instrument for up to 16 hours. The EGM-5 is supplied with an external AC power adapter to charge and/or power the EGM-5.

Battery Specification

- **Type:** Rechargeable Smart Lithium Ion Battery Pack
- **Power**: 7.2V, 8.7Ahr, 63Whr

Note, if the EGM-5 is used with external sensors/chambers it will reduce the battery life depending on the probe connected.

A dead battery (0% capacity) can be fully recharged in approximately 4-5 hours using the power supply/charger supplied by PP Systems.

To check the battery status, simply power up the instrument and observe the battery capacity next to the flashing heartbeat in the upper left hand corner of the display (see below).
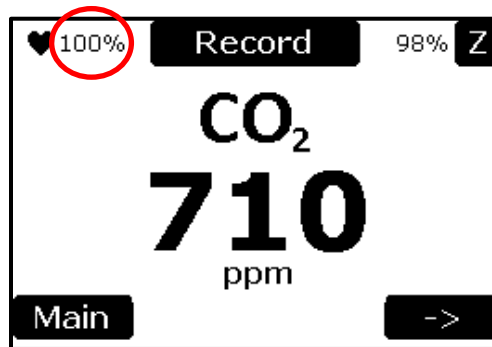
Power Supply/AC Adapter Rating:

- **Input:** 100-240 VAC, 50-60 Hz, 1.0A
- **Output:** 12 VDC, 3.3A

Re-Order Information	
Part Number	**Description**
STD561	Mains Charger/Power Supply

Getting Familiar with the EGM-5

Adjustable Carry Handle

CO_2 scrubber status and manual Zero button

Flashing Heart (Power Status) and battery capacity

Touch display

Polyurethane shock-absorbing base and battery compartment

Touch Display

The EGM-5 features a 2.7" a-Si, active matrix TFT, Electronic Paper Display (EPD) touch panel. The panel has such high resolution (117 dpi) that it is able to easily display fine patterns with excellent readability under sunlight conditions. Due to its bi-stable nature, the EPD panel requires very little power to update and needs no power to maintain an image.

Features

- a-Si TFT active matrix Electronic Paper Display (EPD)
- Resolution: 264 x 176 pixel
- Ultra-low power consumption
- Super Wide Viewing Angle - near 180°
- Slim & lightweight enclosure
- SPI interface
- RoHS compliant

Navigation using the Touch Display

Navigating through the system is simple and easy by pressing black buttons where applicable. Whenever you see white text inside a black box we refer to this as a button (i.e. **Main**). Pressing on these buttons will allow you to set up, navigate and operate the EGM-5. Whenever a numeric value is required, a keypad will appear allowing you to enter the desired values.

Back of EGM-5

USB Flash Drive　　　USB Mini-B

Power Switch

External Power/Charger socket

External Power LED Indicator

Probe 1 Input

Probe 2 Input

Gas Out

Gas In

Absorber column and CO₂ scrubber

10 Pin Terminal Block
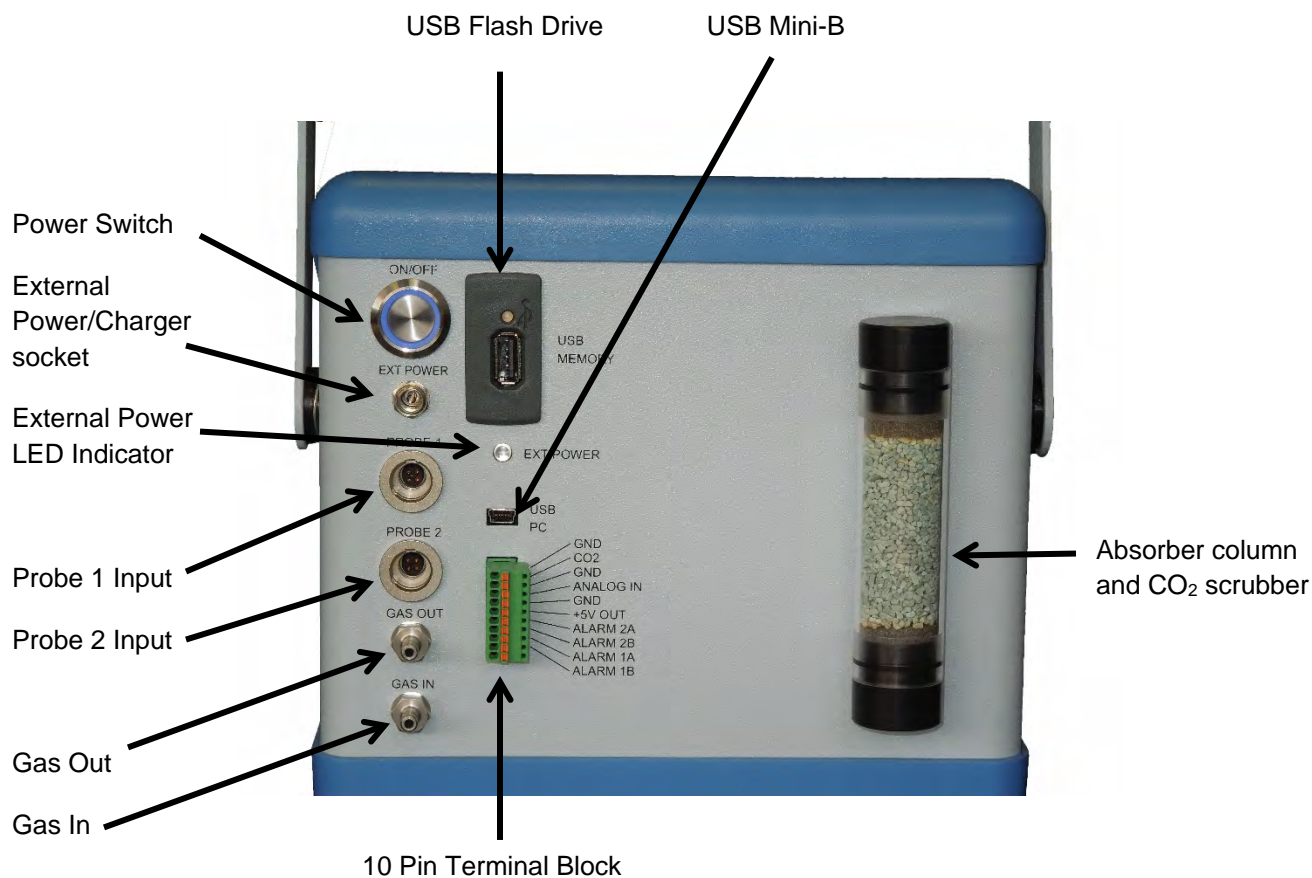
Power Switch

The power switch is located in the upper left hand corner of the back panel. To power up the EGM-5 simply push in the switch. When power is on the illumination ring around the switch will turn blue. To turn off, simply press the switch again bringing it back to the flush position. When powered off, the Splash Screen will be displayed as follows:
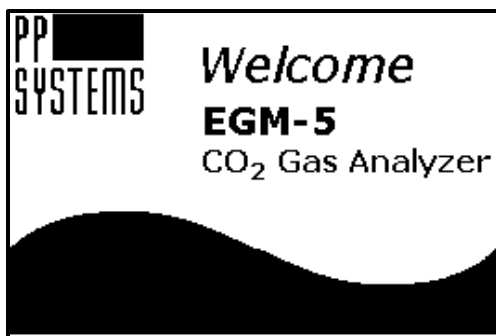
When the EGM-5 is turned off you must wait at least 5 seconds before powering up the instrument. If you do not wait long enough the system will not power up properly.

Please note that the EGM-5 will turn off when the battery capacity reaches 0%. If this happens we recommend connecting up to the charger to recharge the internal battery.

If the EGM-5 was put into ship mode, it will not power on until external power is applied. To bring the EGM-5 out of ship mode, first connect external power to the instrument, and then turn it on by pressing the "ON/OFF" button. See Ship Mode on page 53 for more information.

Ext Power Jack

When external power is present, the system will charge the internal battery. A power supply/charger is supplied with the EGM-5 as standard. When the power supply/charger is connected to the EGM-5 it will both operate the instrument continuously and recharge the internal battery when the EGM-5 is powered on. If connected to the EGM-5 with power off it will recharge the internal battery faster.

Ext Power LED

The amber LED is illuminated whenever the power supply/charger is connected to the **EXT POWER** jack on the back panel.

Gas Ports

There are two gas ports on the EGM-5. Each port is designed for use with 1/8" (.125") ID tubing or a mating quick disconnect. When using the EGM-5 as a stand-alone CO2 analyzer, the sampling line should be fitted to the **GAS IN** port and the **GAS OUT** port should be left open to atmosphere to allow the sample air to exhaust without restriction. This does not apply when using some optional accessories (e.g., the SRC-2 Soil Respiration Chamber or the CPY-5 Canopy Assimilation Chamber).

Flow Rate

The EGM-5 features an internal electronic flow sensor for controlling flow rate between 100-500 cc/min. The flow rate is adjustable by changing the Pump Power percentage in Flow Setting. To set/change the flow rate from the Main menu, touch Main, Settings and Flow.

Flow Setting

Flow (cc/min): 323

Pump Power (%): 40

To change Pump Power, press on % value (with black background) and enter your required % from 0-100. We strongly recommend a flow rate of approximately 280-350 cc/min for optimal performance.

Important Note. If the flow rate drops below 50 cc/min, a "low flow" error message will be displayed in the status box. Typically this is the result of flow restriction caused by either the external air filter or a blocked internal hydrophobic filter located inside the EGM-5 enclosure. First, replace the external air filter connected to the **GAS IN** port to see if this corrects the problem. If it doesn't then the likely problem is a blocked internal hydrophobic filter See Hydrophobic Filter on page 123 for information related to changing this filter.

USB Flash Drive Port

A USB Flash Drive Port is available on the back panel to allow users to save data directly to a USB flash drive (also commonly referred to as a "thumb drive" or "memory stick"). When a USB flash drive is inserted into the USB port, the LED indicator will first turn red in recognition of the USB flash drive and then it will flash green indicating that data is being saved to it automatically. If the indicating LED is a steady green then data is not being saved because the "Interval (sec)" is likely set to 0 under Memory Measure Settings. See Memory Measure Settings on page 48 for more information on this.

USB PC Port

The USB PC Port (USB Mini-B) can be used to connect the EGM-5 to a PC. Measured data is continuously sent through this port. The PP Systems' GAS software or a terminal emulation program (i.e. HyperTerminal) can then monitor the measured data. GAS software is supplied on the USB flash drive supplied with the EGM-5 and it is also available for free download from our website. When using a terminal emulator, the COM port settings to communicate with the EGM-5 are: 19200 baud, 8 bit, 1 stop, no parity, no flow control.

Probe Ports

There are 2 digital **PROBE PORTS** available for use with external sensors/accessories. The current list of supported probes/sensors include:

- Quantum Sensor (Apogee Instruments)
- TRP-3 Temperature & PAR Probe
- STP-2 Soil Temperature Probe
- SRC-2 Soil Respiration Chamber
- CPY-5 Canopy Assimilation Chamber
- Soil Moisture & Temperature Sensor (Stevens Water Monitoring Systems)

Up to two different probes can be used at the same time, for example, the SRC-2 Soil Respiration Chamber and the STP-2 Soil Temperature Probe. Note that some combinations of the above probes will not be possible, for example, the TRP-3 and SRC-2 Soil Respiration Chamber.

Terminal Block

An external 10 pin terminal block is available for CO_2 analog output, analog input (for additional sensor), +5V OUT and alarms.

CO2 Analog Output	
GND	Ground connection for CO_2 analog output
CO2	Analog output for CO_2 (0-2.5V). 0 corresponds to 0 CO_2 and 2.5V corresponds to full scale (defined by user).
Analog Input	
GND	Ground connection for analog input
ANALOG IN	Analog input for external sensor (0-1V). The input voltage is displayed and saved in the data output as a voltage signal. The user can then convert the voltage signal into the appropriate value depending on the sensor used.
+5V OUT	Additional 5V power supply for external sensors if required. It is recommended that no more than 400mA of current be used.
Alarms	
ALARM 2A	Associated with Low Alarm. The relays are rated for 30 VDC 1A or 125 VAC 0.3 A.
ALARM 2B	Associated with Low Alarm. The relays are rated for 30 VDC 1A or 125 VAC 0.3 A.
ALARM 1A	Associated with High Alarm. The relays are rated for 30 VDC 1A or 125 VAC 0.3 A.
ALARM 1B	Associated with High Alarm. The relays are rated for 30 VDC 1A or 125 VAC 0.3 A.

Analog Voltage Output

One analog voltage output is available for the current CO_2 reading. The full scale output is 2.5V. The CO_2 concentration corresponding to full scale can be set by the user in the Main > Settings 2 > Analog Output screen. 0 Volts always corresponds to 0 ppm CO_2. The analog voltage output is located on the terminal block at the pins labeled CO2 (positive) and GND (negative).

Analog Voltage Input

One analog voltage input is available for general purpose use. The maximum input voltage is 1.0V. The input voltage is displayed and saved in the data measurements.

Alarm Relay Outputs

There are two normally open relay contacts that are activated (closed) when the Low CO_2 Alarm (Alarm 1) or High CO_2 Alarm (Alarm 2) condition occurs. The Alarm limits are set in Main > Settings 1 > Alarms. The relays are rated for 30 VDC at 1A or 125 VAC at 0.3 A. The 5V output could be connected to one side of these relays to create a digital output signal. Relays can also be used to trigger an external device such as a computer or warning light.

Recommended Cable Interface

When connecting up to external devices via the EGM-5 terminal block we recommend the following cable type and lengths.

EGM-5 Terminal Block

GND	P1
CO2	P2

Shielded cable to Data Logger or Programmable Logic Controller

Typical cable Belden 8413 2C 24 Shielded. Length 10 Ft Maximum.

GND	P3
Analog In	P4
+5v	P6

Shielded cable to Sensor or External Zero Switch

Typical cable Belden 8413 2C 24 Shielded. Length 5 Ft Maximum.

GND	P5
Alarm 2A	P7
Alarm 2B	P8
Alarm 1A	P9
Alarm 1B	P10

Shielded cable to external relays or Programmable Logic Controller

Typical cable Belden 9609 4C 24 Shielded. Length 10 Ft Maximum.

Absorber Column and CO_2 Scrubber

The absorber column contains a CO_2 scrubbing desiccant commonly referred to as "soda lime". When air passes through this column, it removes all of the CO_2 from the air stream. The "Auto-Zero" function built into the EGM-5 periodically switches the flow of gas from the analyzer through this column to check the analyzer zero. This routine ensures long term stability and accuracy of the CO_2 analyzer. It automatically corrects for such things as sample cell contamination, source aging, detector sensitivity and changes in electronics. The default Auto-Zero interval is 20 minutes, but this can be changed if required. See Zero Settings on page 34.

Important Note

It is critical that the soda lime is fresh to ensure that the EGM-5 receives a good zero for long term calibration and stability of the CO_2 signal. At present, both self-indicating and non-indicating soda lime can be used with the EGM-5. If using a self-indicating desiccant you can visually determine when the desiccant is exhausted by change in color. When the desiccant is more than 2/3 exhausted you should replace it. In addition, the EGM-5 monitors the CO_2 scrubber condition in the upper right hand corner of the display based on use (see below). This is extremely helpful when using a non-indicating CO_2 scrubber. We recommend changing out the desiccant daily or at minimum when this value gets to 20%.
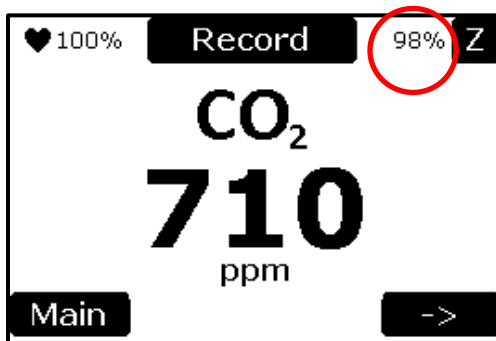
See Reset Abs Settings on page 38 for information on resetting the CO_2 scrubber after refreshing the desiccant.

Soda Lime (CO_2 Scrubber)

The EGM-5 is virtually maintenance free. However, the condition of the soda lime should be carefully inspected before each use to ensure stability and accuracy of CO_2 measurements. Generally speaking, the soda lime should last for several weeks during regular use. However, given the importance of stability and accuracy of the CO_2 signal you should consider changing out this desiccant more frequently as described above (daily).

! CAUTION !

WASH YOUR HANDS AFTER HANDLING SODA LIME

Routine System Checks Before Starting

The EGM-5 is designed to operate with minimal maintenance. The basic routine system checks are as follows:

- Make sure the external air filter (Part No. STD558) is fitted to the **GAS IN** port. This will ensure that the sample air is filtered before entering the system.

- Check the absorber column on the back and make sure that it is properly seated in its manifold. You should periodically lubricate all O-rings associated with the column (black end caps) with silicone grease to ensure good seal and to avoid problems associated with cracks and leaks. Also ensure that the gray foam filters are in good shape and replace when worn.
- Check the condition of the CO_2 scrubber (i.e. soda lime) and make sure it is fresh. If you are using self-indicating soda lime you can visually make this determination. If you are using non-indicating soda lime then power up the instrument and check the status (see below). If below 20% you should change it and reset the absorber column life. See Reset Abs Settings on page 38.
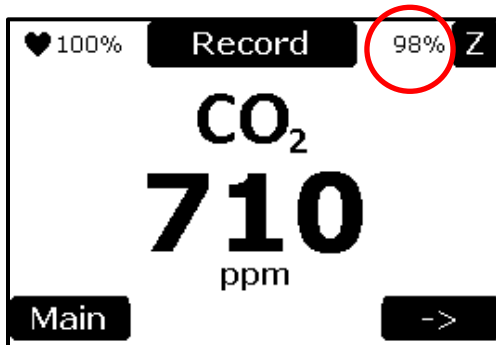
- **System Power and Heartbeat -** Make sure that the heart symbol is flashing in the upper left hand corner after the instrument is powered on. Also check the battery capacity next to the heart to ensure that you have plenty of power to get you through your measurements.
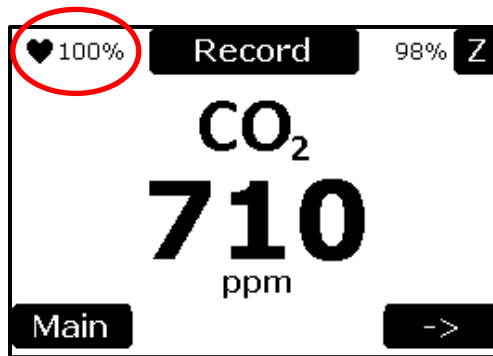
- **USB Flash Drive –** You must make sure that you have a USB flash drive (memory stick) plugged in for data storage. **If you do not have this you will be unable to save data, and it will have to be recorded manually.**
- **Status Box** – Inspect periodically for error messages/warnings.

Touch Display Overview

The flowchart on the following page describes an overview of the touch display for the EGM-5. When the instrument is first powered up, there is a brief period where the Splash screen is shown. After this time, the instrument goes into the warm-up period which is approximately 10-15 minutes and the Measure screen is displayed. During and after the warm-up period, the user has the ability to navigate through the menus as shown in the flowchart below. The following sections describe each screen and its functionality.

Heartbeat and Display Update Rate:

The flashing heartbeat ♥ icon is updated each time the **display** is updated (whether the CO_2 or other values change or not). Normally the display is updated every 1 second. However, in extended mode the **display** is updated every 5 seconds (even though data is still being output and recorded every 1 second). The extended mode saves power and prevents display ghosting. Extended mode begins approximately 30 seconds after the last keypress is made on any measurement screen. Return to normal 1 second update rate will occur when:

- Any screen button is pressed
- The heartbeat icon is pressed
- Any new CO2 reading is more than 10% changed from the previous CO2 reading.
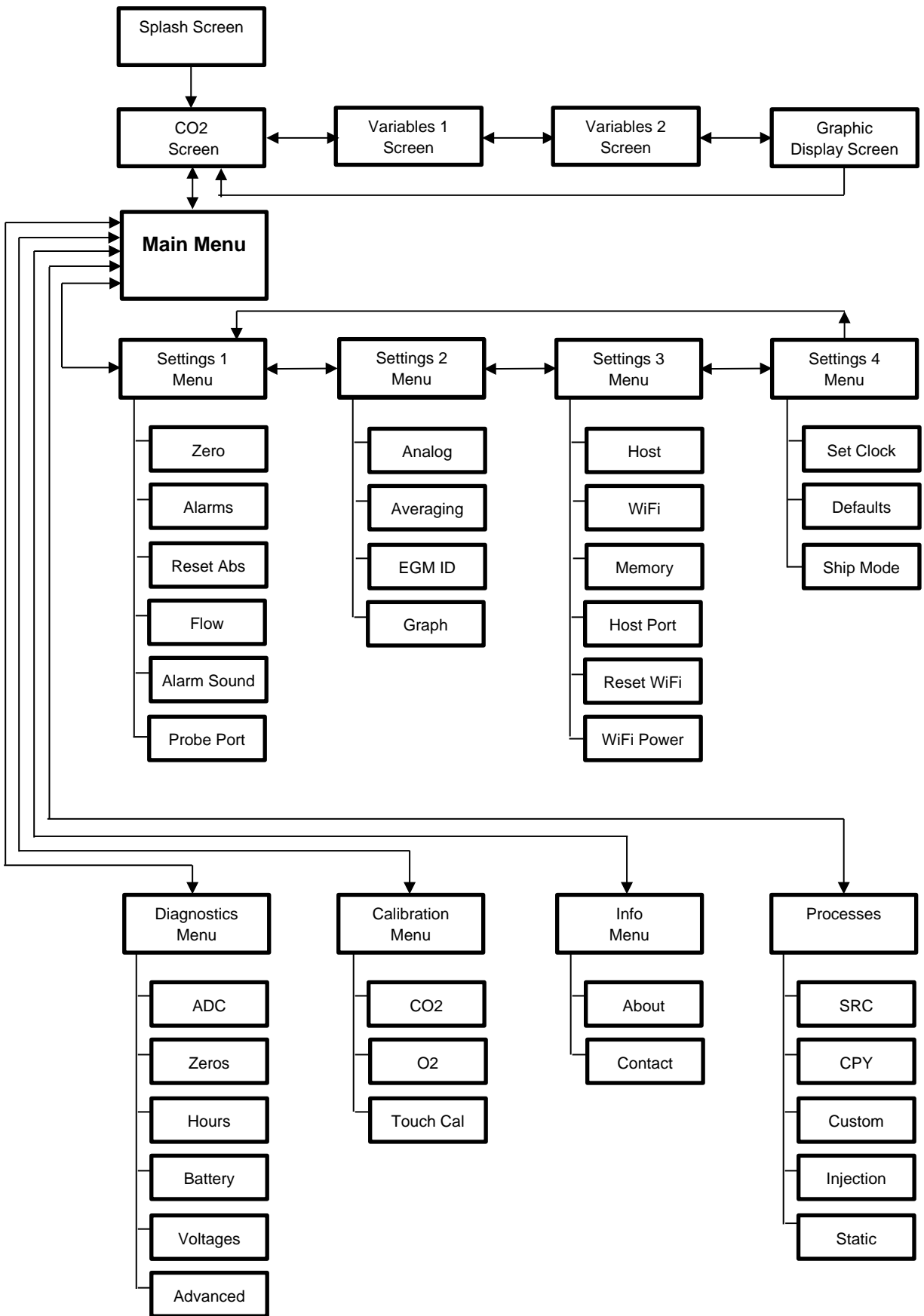
Splash Screen

The Splash screen is always shown on the display when the EGM-5 is off. When the instrument is first powered up, the Splash screen is displayed momentarily followed by the Measure screen displaying CO_2 in large text.
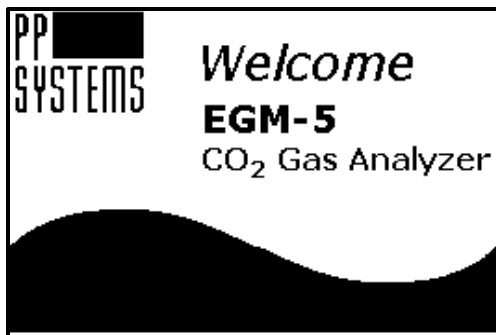
Measurement Mode

The Measurement Mode is comprised of four screens:

1. Measure screen
2. Readings screen
3. Probe screen
4. Graphic display screen

Each screen allows the user to view the EGM-5 data in various ways. The screens can be rotated through by the user using the left (< -) and right (- >) arrow buttons. Generally speaking, the left arrow brings you back to the previous screen and the right arrow to the next available screen. The initial screen is the Measure screen which displays the value of CO_2 concentration in a large bold font. The next screen is the Readings screen and displays the values of six parameters in real time; CO_2, H_2O, O_2, Temperature, Flow Rate, and Pressure. The third screen is the Probe screen which displays the values of six parameters in real time; CO_2, PAR, Aux, air temperature (Tair), soil temperature (Tsoil) and soil moisture (Msoil). The fourth screen Graphic Display screen which displays CO_2, H_2O or O_2 concentration graphically over time.

Each screen contains common features. There is a flashing ♥ icon to confirm that the EGM-5 is on (power status). The percentage value in the top left corner is the percentage of battery remaining. The percentage value in the top right corner is the percentage of absorber column remaining. Also, a manual zero can be initiated using the "Z" button. A status or error message can be displayed in the Status Box. Each Measurement screen is explained in more detail below.

Measure Screen

The Measure screen is displayed after the Splash screen once the EGM-5 is powered up. For the first 10-15 minutes, the EGM-5 goes into a warm-up period until it achieves its final temperature of 55°C and a zero check is performed. During this time, messages are displayed in the Status Box that indicate that the instrument is in the warm-up stage (see below). During warm-up, the CO_2 value is displayed as 0 ppm.
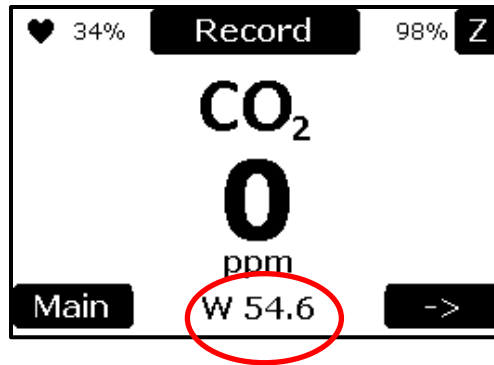
At the completion of the warm-up period, the proper CO_2 value is displayed and the Status Box is blank.
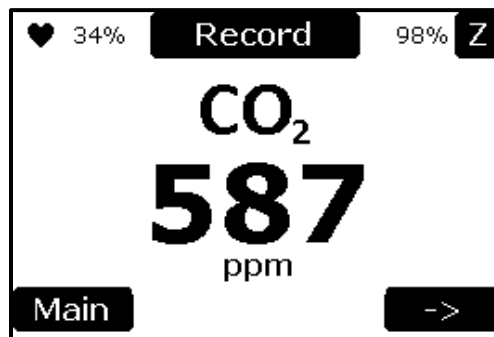
Measure Screen	
♥ (Heartbeat)	Pulses on and off to indicate that the system is powered and operating. Press to return to normal 1 second display updates.
34%	Percentage of battery life remaining.
Record	Saves current data as a marked record in the USB Memory stick and also sends the record to the host and WiFi ports
98%	Percentage of CO_2 scrubber (soda lime) remaining. We recommend changing out the scrubber when it gets to 20%.
Z Button	Initiates a manual zero.
CO_2	Current measurement of CO_2 Concentration (ppm)
Main Button	The Main screen is displayed when this button is selected. See Main Menu on page 33 for more details.
Status Box	Any information or error messages are displayed here.
Right Arrow	Starts the rotation through the 4 available Measurement Mode screens.

The Main and right arrow buttons are operational during and after the warm-up period. The Main button is the top level Main Menu for settings and user functionality of the system. The arrow button will bring you to the next available screen. The flashing ♥ icon in the top left corner indicates that the system is powered on (power status). The percentage value in the top left corner (34%) is the percentage of battery remaining. The percentage value in the top right corner (98%) is the percentage of absorber column remaining. The "Z" button in the top right corner performs a zero when pressed. The Status Box informs the user of any status or error messages.

Readings Screen

The Readings Screen displays the values of six parameters in real time; CO_2, H_2O, O_2, Temperature, Flow Rate, and Pressure. All of these sensors (if included) are located inside the EGM-5 console. Every EGM-5 will include CO_2, Pressure and Flow Rate. If the optional H_2O and/or O_2 sensor is included then these readings will also be displayed and recorded. If the H_2O and/or O_2 sensor is not included the readings will show 0.

Readings Screen	
♥ (Heartbeat)	Pulses on and off to indicate that the system is powered and operating. Press to return to normal 1 second display updates.
71%	Percentage of battery life remaining.
Record	Saves current data as a marked record in the USB Memory stick and also sends the record to the host and WiFi ports
90%	Percentage of absorber column remaining.
Z Button	Initiates a zero.
CO2	CO_2 concentration reading (ppm).
Pr	Absolute pressure in sample cell (mb).
Fl	Flow rate reading (cc/min).
H₂O	H_2O reading if optional H_2O sensor is installed (mb).
T	Temperature of the sample gas at the optimal H_2O sensor if optional H_2O sensor is installed (°C).
O₂	O_2 reading if optional O_2 sensor is installed (%).
Left Arrow	Displays the previous Measurement Mode screen (the Measure screen).
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to the next Measurement Mode screen (the Probe screen).

Probe Screen

The Probe Screen displays the values of six parameters in real time; CO_2, PAR, Aux(**ANALOG IN**), air temperature (Tair), soil temperature (Tsoil) and soil moisture (Msoil). All readings, with the exception of CO_2, are based on optional external sensors which may be used with the EGM-5.

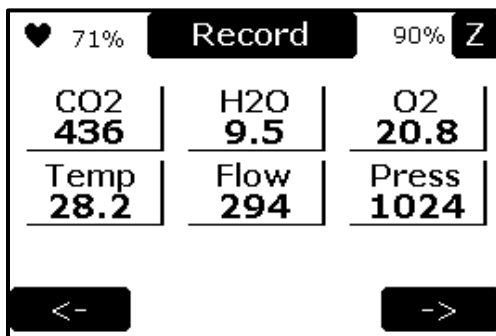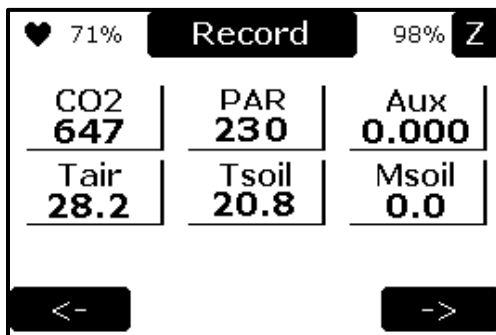| Readings Screen 2	
♥ **(Heartbeat)**	Pulses on and off to indicate that the system is powered and operating. Press to return to normal 1 second display updates.
71%	Percentage of battery life remaining.
Record	Saves current data as a marked record in the USB Memory stick and also sends the record to the host and WiFi ports
98%	Percentage of absorber column remaining.
Z Button	Initiates a zero.
CO_2	CO_2 concentration reading (ppm).
PAR	PAR sensor reading ($\mu mol\ m^{-2}\ s^{-1}$).
Aux	Aux input, also referred to as Analog In (V).
Tsoil	Soil temperature reading (°C).
Tair	Air temperature reading (°C).
Msoil	Soil moisture (%)
Left Arrow	Displays the previous Measurement Mode screen (the Readings screen).
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to the next Measurement Mode screen (the Graphics Display screen).

Graphic Display Screen

The Graphic display screen shows a real-time display of the CO_2 concentration data.
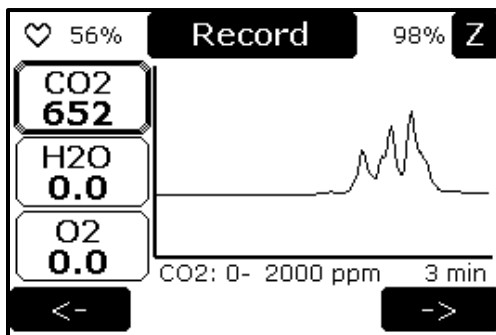
Graphical Display Screen

♥ (Heartbeat)	Pulses on and off to indicate that the system is powered and operating. Press to return to normal 1 second display updates.
56%	Percentage of battery life remaining.
Record	Saves current data as a marked record in the USB Memory stick and also sends the record to the host and WiFi ports
98%	Percentage of absorber column remaining.
Z Button	Initiates a zero.
CO2 Button	Current measurement of CO_2 concentration in ppm, and when pressed changes graphed parameter to CO_2
H₂O Button	Current measurement of H_2O partial pressure in mb, and when pressed changes graphed parameter to H_2O (0 - 30 mb)
O₂ Button	Current measurement of O_2 concentration in %, and when pressed changes graphed parameter to O_2 (0-100%)
0-2000 ppm	Y-axis range and units (CO_2 concentration).
3 min	X-axis time; fixed value of 3 minutes.
Left Arrow	Displays the previous Measurement Mode screen (the probe screen).
Status Box	Any information or error messages are displayed here.
Right Arrow	Completes the rotation of the Measurement Mode screens and returns to the Measure screen..

The moving horizontal line below the CO_2 concentration value indicates where on the timeline the graph data is being displayed. The y-axis maximum (CO_2 concentration) is the number located under the graph on left side (for example, 10000 ppm). The X-axis maximum (time) is the number located under the graph on the right side. The x-axis maximum is a fixed value of about 4 minutes.

The maximum CO_2 value can be set in the Graph Settings screen. See Graph Settings on page 45 for more details.

Main Menu

The Main Menu screen is displayed when the Main button is selected in the Measure screen. This menu is the top level menu for all settings and user functionality of the system.

```
              Main Menu
    Settings        Calibration
    Diagnostics        Info
    Processes

    Back
```
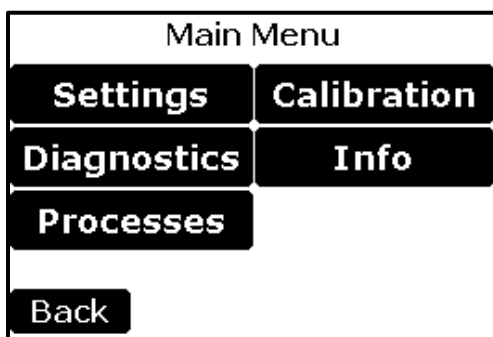
Main Menu	
Settings	Controls major settings of the EGM-5. There are four sub menus under Settings. See Settings on page 33.
Diagnostics	Performs system diagnostics for troubleshooting purposes. See Diagnostics on page 83 for more details.
Processes	Performs the EGM-5 Processes available depending on probe/sensor used with the EGM-5. See Processes on page 54 for more details.
Calibration	Used to calibrate the CO_2 gas analyzer and O_2 sensor and the Touch Screen. See Calibration on page 77.
Info	Contains version information and contact information.
Back	Returns to the Measure screen.
Status Box	Any information or error messages are displayed here.

Settings

There are four settings menus; Settings 1-4. Generally, the settings have been grouped related to their common functionality. For example, Settings Menu 1 contains the first tier of major settings for the EGM-5. Settings Menu 2 contains the second tier set of settings for the EGM-5. Settings Menu 3 contains options for adjusting the Measurement Format and Interval for the Host, WiFi, and Memory data outputs. Settings Menu 3 also contains settings for the Host Port, resetting WiFi configuration, and turning WiFi power on or off. Settings 4 handles the less common settings of the EGM-5.

Settings 1 Menu

This menu contains the first tier and most common settings for the EGM-5 including the Zero, Alarms, Reset Abs (Reset Absorber Column), Flow, Alarm Sound and Probe Ports settings.

Settings 1 Menu	
Zero	Change/view the settings of the zero parameters (zero type and time interval for performing zeros).
Alarms	Change/view the high and low alarm settings built into the EGM-5. The alarm parameters are low and high CO_2 alarm set points.
Reset Abs	Indicate that absorber material has been replaced.
Flow	Change/view the pump power and view the flow rate.
Alarm Sound	Change/view the alarm sound. This setting enables/disables the alarm sound.
Probe Ports	Change/view the settings of Probe Ports 1 and 2.
Back	Returns to the Main Menu.
Right Arrow	Continues to the Settings 2 Menu screen.

Zero Settings
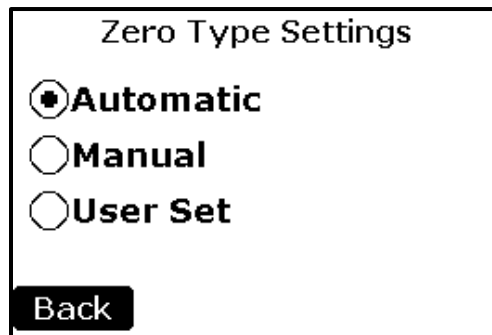
This function allows the user to change/view the settings of the zero parameters used by the EGM-5.

Zero Settings	
Zero Type	There are three types of zeros that can be performed; Automatic, Manual and User Set. See Zero Type below for more details. **We recommend Automatic.**
Time (min)	Zero time is the interval between zeros in minutes when Zero Type is set to User Set. See Zero Time on page 36 for more details.
Back	Returns to the Settings 1 Menu.

Zero Type

To change the Zero Type, select the button to the right of the "Zero Type:" text in the Zero Settings screen. The Zero Type Settings will display radio buttons with the current selection indicated.
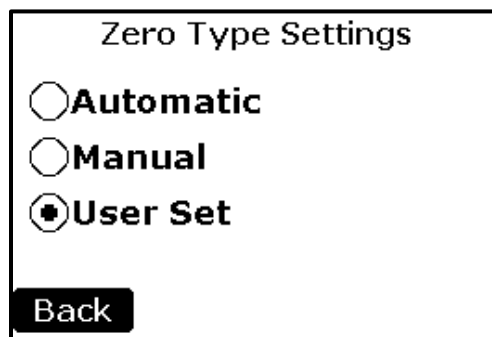
```
        Zero Type Settings
  (●)Automatic
  ( )Manual
  ( )User Set

  [ Back ]
```

Press the desired setting (in this case, User Set) either directly on the radio button or on the text to the right of the radio button.
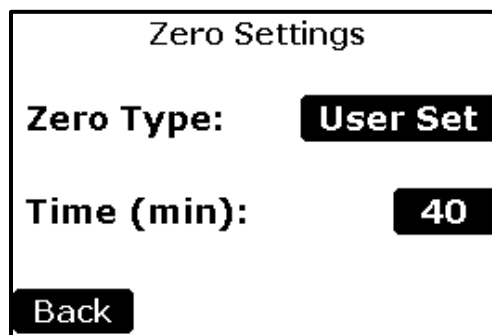
```
        Zero Type Settings
  ( )Automatic
  ( )Manual
  (●)User Set

  [ Back ]
```

Then select the Back button to return to the Zero Settings screen. The Zero Settings screen will return with the updated Zero Type value in the button box.

```
          Zero Settings

  Zero Type:      [ User Set ]

  Time (min):        [ 40 ]

  [ Back ]
```

Press the "Back" button to return to the Settings 1 Menu.

Zero Type Settings	
Automatic	This is the recommended Zero Type. The EGM-5 performs a zero on start up, then again after 3 minutes, then again after 6 more minutes, then after 12 minutes, then every 20 minutes thereafter. The Zero Time interval is fixed at 20 minutes. This is the default mode upon initialization.
Manual	A zero can be initiated at any time and regardless of the Zero Type Setting by pressing the Z button in the upper right hand corner of the display. It can also be initiated externally if required. In this mode, a zero is performed when a high level signal between 0.7 V and 5.0 V is present on the ANALOG IN pin on the on the terminal block for 3 seconds. The ANALOG IN pin is normally 0 V. A contact closure between the ANALOG IN pin and the +5V Out pin will initiate a zero. In this mode, no startup zeros are performed.
User Set	When selected, the EGM-5 performs a zero on start up, then again after 3 minutes, then again after 6 more minutes, then after 12 minutes, then finally after 20 minutes. It then performs zeros at the user-specified interval. It can be set from 1 to 11,000 minutes (~7 days). For a setting greater than 40 minutes, see Zero Time on page 36 for more details.

Important Note

An Auto Zero can be performed at any time either automatically or using the "Z" button in the Measure, Graphic Display, Readings or Probe screens. In this case, the timer resets back to zero and will perform another zero when the Zero Time interval has elapsed.

Zero Time

To change the Zero Time, select the button to the right of the "Time (min):" text in the Zero Settings display (see display above). A numerical keypad will appear. This setting is only available when Zero Type is in User Set mode.

This numerical keypad will be displayed for any parameter requiring numerical input. A description of the numerical keypad components, using the example of the Zero Time parameter, is shown in the table below. In this example, if the OK button is selected, the value of 30 will replace 40 in the Zero Time parameter in the Zero Settings screen. If Cancel is selected, Zero Time will continue to display 40 minutes.

Numerical Keypad	
Title (Zero Time)	This is the title of the parameter being modified. In this case, Zero Time is the title of the parameter.
Units (min)	The units of the parameter are displayed in parentheses. In this case, min or minutes are the units for this parameter
Range ([1-40])	The valid range of parameter values is displayed in brackets. In this case, the Zero Time parameter have valid values from 1-40.
Value (30)	The updated value of the parameter is displayed after the "=" sign. In this case, the Zero Time parameter is set to 30.
0-9, . , Del Buttons	These buttons are used to input a numerical value.
OK Button	The OK button accepts the entered value and returns to the previous screen.
Cancel Button	The Cancel button returns to the previous screen without saving any changes.

Important Note

PP Systems recommends Zero Time to be set to 40 minutes or less. Without frequent auto-zeroing, the EGM-5 could potentially drift and lose calibration accuracy beyond the 1% specification.

For those customers who are in a very stable environment and where the auto-zero sequence causes experimental problems, higher than 40 minutes can be used, but it should be used with extreme caution.

Once the desired values are displayed in the Zero Settings screen, the "Back" button is selected to return to the Settings 1 Menu.

Alarms Settings

This function allows the user to change/view the low (ALARM1) and high (ALARM2) alarm functions that are built into the EGM-5. An alarm consists of an audio beep (if enabled in the Alarm Sound Setting screen), an information message in the Status Box in the Measurement Mode screens and a relay switch closure. There is a relay switch for each alarm: low (ALARM1) and high (ALARM2).

Alarm Settings

Low CO2(ppm): 250

High CO2(ppm): 2000

Back

Alarm Settings	
Low CO2 (ppm)	Sets the low CO_2 alarm setting. The default low alarm setting is 250 ppm.
High CO2 (ppm)	Sets the high CO_2 alarm setting. The default high alarm setting is 2000 ppm.
Back Button	Returns to the Settings 1 Menu.

Low CO$_2$ Alarm Setting

To change the Low CO$_2$ Setting, select the button to the right of the "Low CO2 (ppm):" text. The numerical keypad will appear, allowing the user to enter a new value.

The EGM-5 is supplied with a factory default low alarm setting of 250 ppm. A low CO$_2$ value is typically the result of one of the following scenarios:

- Low or no air flow.
- Absorber column exhausted (soda lime).
- Zero valve failure.

The Low CO$_2$ Alarm relay (ALARM1) is closed when the CO$_2$ reading is below the Low CO$_2$ set point.

High CO$_2$ Alarm Setting

To change the High CO$_2$ Setting, select the button to the right of the "High CO2 (ppm):" text. The numerical keypad will appear, the user to enter a new value.

The default EGM-5 high alarm setting is 2000 ppm.

The High CO$_2$ Alarm relay (ALARM2) is closed when the CO$_2$ reading exceeds the High CO$_2$ set point.

Once the desired values are displayed, select the "Back" button to return to the Settings 1 Menu.

Reset Abs Settings

This function allows the user to indicate that the absorber material in the column has been replaced, updating the percentage remaining to 100%. This value is displayed in the Measurement Mode screens in the top right corner of the display.

Reset Abs Settings	
YES	Resets the absorber column percentage to 100%. This value is displayed in Measurement Mode screens in the top right corner of the display.
NO	Cancels out and the absorber column percentage value is not reset. Display returns to Setting 1 Menu.

Flow Settings

This function allows the user to change/view the Flow rate of the EGM-5.

```
               Flow Setting

   Flow (cc/min):        288

   Pump Power (%):      45


   Back
```

Flow	
Flow (cc/min)	Displays the real-time value of the Flow rate (cc/min).
Pump Power (%)	Sets the % power of the pump. The range is 0-100%.
Back Button	Returns to the Settings 1 Menu.

Pump Power

To change the Pump Power value, select the button to the right of the "Pump Power (%):" text. The numerical keypad will appear allowing a new number to be entered. After entering the desired value, press the "S1" button to return to the Settings 1 Menu.

Alarm Sound

This function allows the user to change/view the settings associated with the built-in alarm. This parameter sets the alarm sound (beep) to either be audible (Yes) or mute (No).

```
           Alarm Sound Setting


   Alarm Sound:       Yes




   Back
```

Alarm Sound Settings	
Alarm Sound	Sets the Alarm Sound value to either Yes or No. The default Alarm Sound setting is Yes.
Back Button	Returns to the Settings 1 Menu.
Status Box	Any information or error messages are displayed here.

To change the Alarm Sound value, select the button to the right of the "Alarm Sound:" text. The Alarm Sound settings will be displayed, with the current selection indicated.

Press the desired setting and then the Back button. The Alarm Sound Setting screen will return with the updated Alarm Sound value in the button text.

Press the "Back" button to return to the Settings 1 Menu.

Probe Port Settings

This function allows the user to change/view the probes that are connected to ports 1 and 2.

Probe Port Settings	
Probe Port 1	Sets port 1 probe type. Probe options are: Standard, Quantum, Soil Temperature, and Soil Moisture.
Back Button	Returns to the Settings 1 Menu.

Probe Port 1 Settings

To change the Port 1 probe type, select the button to the right of the "Probe Port 1:" text. The Probe Port 1 settings will be displayed, with the current selection indicated.

```
         Probe Port 1 Sensors
         ◯ Standard
         ◯ Quantum
         ⦿ Soil Temperature
         ◯ Soil Moisture


         Back
```

Probe Port 1 Settings	
Standard	For use with the following probes manufactured by PP Systems: • SRC-2 Soil Respiration Chamber • CPY-5 Canopy Assimilation Chamber • TRP-3 Temperature/PAR Probe
Quantum	For use with the Apogee Quantum Sensor
Soil Temperature	For use with the STP-2 Soil Temperature Probe.
Soil Moisture	For use with the Stevens Soil Moisture Sensor.
Back Button	Returns to Probe Port Settings.

Press the desired setting and then the Back button. The Probe Port Settings screen will return with the updated Probe Port 1 value displayed.

Probe Port 2 Settings

Probe Port 2 is for use only with the following 'Standard' probes manufactured by PP Systems:

- SRC-2 Soil Respiration Chamber
- CPY-5 Canopy Assimilation Chamber
- TRP-3 Temperature/PAR Probe
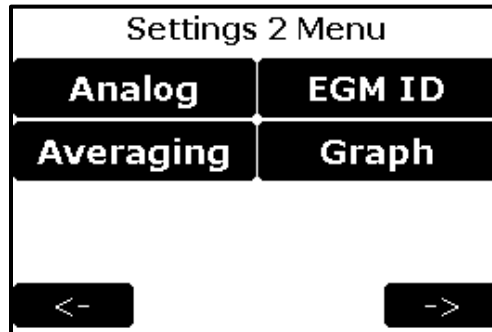
There is no need to change or set the Probe Port type, the EGM-5 will recognize the Probe that is attached to the Probe Port 2 and make the appropriate setting internally.

Important Note

If you are connecting two probes to the EGM-5 simultaneously, any non-PP Systems manufactured sensors probes must be connected to Probe Port 1. For instance, if you are using both the SRC-2 Soil Respiration Chamber and Quantum sensor manufactured by Apogee Instruments, the Quantum sensor should be connected to Probe Port 1 and the SRC-2 Soil Respiration Chamber to Probe Port 2.

Settings 2 Menu

This menu handles the second tier of settings for the EGM-5 including the Analog, Averaging, Graph, EGM ID, About and Display settings.
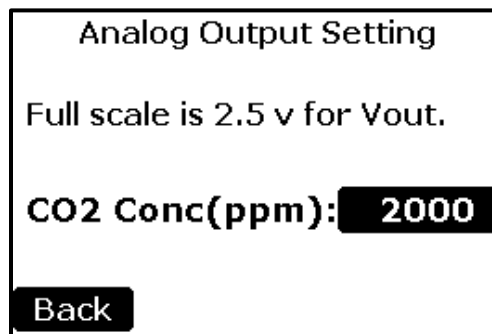
Settings 2 Menu	
Analog	Change/view the analog output. This parameter controls the voltage output of the Digital to Analog (D/A) converter in the EGM-5. The maximum output voltage is fixed at 2.5V.
Averaging	Change/view the CO_2 averaging method used by the EGM-5. The CO_2 Averaging Limit parameter can be modified in this screen. The default value is 30 ppm.
Graph	Change/view the settings of the CO_2 concentration maximum value on the Graphic display screen. The default value is 1000 ppm.
EGM ID	Assigns an ID number to the EGM-5, useful for situations in which more than one EGM-5 is used simultaneously. The default ID is 1.
Left Arrow	Returns to the Settings 1 Menu.
Right Arrow	Continues to the Settings 3 Menu screen.

Analog Output Settings

This function allows the user to change/view the analog output. This setting controls the voltage and current output from the D/A converter in the EGM-5.

Analog Output Settings	
CO2 Conc (ppm)	Changes the CO_2 concentration (ppm) associated with the maximum Analog Output voltage (2.5 V).
Back	Returns to the Settings 2 Menu.

To change the CO_2 concentration represented by to the maximum analog output value, select the button to the right of the "CO2 Conc (ppm):" text. The numerical keypad will appear, allowing a new number to be entered.

In the example above, an analog output range of 0-2.5 volts corresponds to a CO_2 measurement range of 0-2,000 ppm. Again, the maximum analog output voltage is 2.5V.

After entering the desired value, press the "Back" button to return to the Settings 2 Menu.

Averaging Settings

This function allows the user to change/view the CO_2 averaging method used by the EGM-5.

The default EGM-5 averaging window is 1 second long. An optional running average function is available to improve resolution and reduce the effect of transient fluctuations.

Running Average: The instrument's response time to a step change is 2.5 seconds to reach 66% of a new value, and 10 seconds to reach 99%, due to the time it takes samples to reach the IRGA. In other words, if an instrument goes from measuring Sample Gas A to Sample Gas B, it would take 2.5 seconds for the CO_2 reading to change by 66% of the difference between the two samples; after 10 seconds, the measured value will be within 1% of the concentration of CO_2 in Sample Gas B. An exponential running average algorithm can smooth out small fluctuations while remaining sensitive to larger differences. When the running average is enabled (by setting Avg Limit greater than 0), the response time is 3.5 seconds to reach 66% of a new value, and 16 seconds to reach 99%. A special feature of this running average algorithm is that whenever a new reading differs from the current running average by more than the CO_2 Avg Limit value, a new running average begins. Thus, when the CO_2 concentration is changing rapidly, averaging is suspended and the instrument can track changes at the basic instrument data rate of 1 second. When the CO_2 Avg Limit is set to 0, no running average is performed. The default CO_2 Avg Limit is 30 ppm. The running average is applied to displayed data, recorded data, and analog output signals.

Averaging Settings	
CO2 Avg Limit (ppm)	The CO_2 Avg Limit is the threshold that new CO_2 readings must exceed in order to trigger the start of a new running average. Values up to 100 ppm are allowed. The default value is 30 ppm.
Back	Returns to the Settings 2 Menu.

To change the CO_2 Averaging Limit, select the button to the right of the "CO2 Avg Limit (ppm):" text. The numerical keypad will appear, allowing a new number to be entered.

After entering the desired value, press the "Back" button to return to the Settings 2 Menu.

EGM ID

This function allows the user to change/view the settings of the EGM ID parameter used by the EGM-5. This parameter sets an identifier for each EGM-5 so data can be differentiated between multiple instruments.

EGM ID	
EGM-5 ID	Sets an identifier for use when more than one EGM-5 is employed simultaneously. The default value is 1.
Back Button	Returns to the Settings 2 Menu.

EGM ID

To change the EGM ID, select the button to the right of the "EGM-5 ID:" text. The EGM ID settings will be displayed, with the current selection indicated.

Press the desired setting and then the Back button and the EGM ID Settings Menu will return with the updated EGM ID setting in the button box.

Press the "Back" button to return to the Settings 2 Menu.

Graph Settings

This function allows the user to change/view the Graph Settings in the Graphic Display screen.

Graph Settings	
Max CO2 (ppm)	This setting determines the maximum CO_2 value to be displayed on the y-axis of the graph in the Graphic Display screen. This value is also displayed in the final step of all processes.
Back	Returns to the Settings 2 Menu.

Max CO_2

To change the Max CO_2 value, select the button to the right of the "Max CO2 (ppm):" text. The Max CO_2 settings will be displayed, with the current selection indicated.
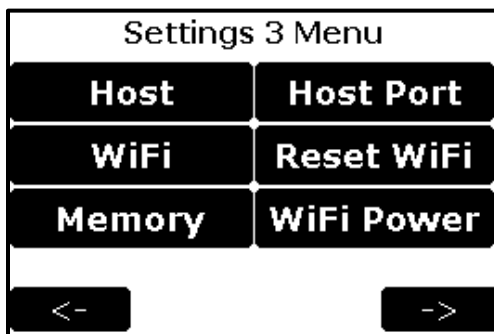
Press the radio button for the desired setting and then the Back button. The Graphic Settings screen will return with the updated Max CO_2 value in the button text.

Once the Max CO_2 Setting is as desired, press the "Back" button to return to the Settings 2 Menu.

Settings 3 Menu

This menu contains a number of settings for the EGM-5, including the Host, WiFi, Memory, Host Port, Reset WiFi, and WiFi Power settings.
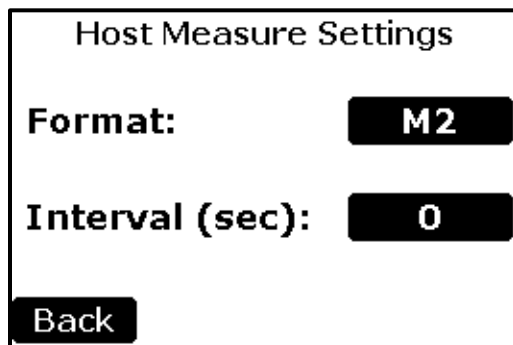
Settings 3 Menu	
Host	Configures the data format and time interval at which measurement data is sent to the Host via a terminal emulation program (e.g., HyperTerminal or PuTTY).
WiFi	Configures the data format and time interval at which measurement data is transmitted via the wireless connection and to the Internet.
Memory	Configures the data format and time interval at which measurement data is sent to the USB memory stick.
Host Port	Change/view the settings of the port connection used by the EGM-5. The options are USB and WiFi.
Reset WiFi	Restore default factory WiFi settings (if WiFi option is installed).
WiFi Power	Turns the WiFi power on or off.
Left	Returns to the Settings 2 screen.
Status Box	Any information or error messages are displayed here.
Right	Continues to the Settings 4 Menu screen.

Host Measure Settings

These settings control the format of measurement data, as well as the interval at which it is sent to the Host (e.g., a PC running HyperTerminal).

Host Measure Settings	
Format	Determines the measurement data format. All data formats are available (M1-M6). The default is M3. See the Measure Format Settings Table on page 93 for more information.
Interval (sec)	Determines the time interval, in seconds, in which data will be transmitted. A value of 0 disables automatic transmission of measurement data, but zero operations and Process operations will still be reported. The maximum value is 3600 seconds (1 hour). Default is 1 second.
Back Button	Returns to the Settings 3 Menu.

Host Measure Format

To change the Host Measure Format, select the button to the right of the "Format:" text. The Measure Format Settings screen will be displayed with the current selection indicated.

Measure Format Settings

Six Measure Format Settings are available. See the Measure Format Settings Table on page 93 for more information.

Press the desired setting and then the Back button and the Measure Format Settings Menu will return with the updated format setting in the button box.

Host Measure Interval

To change the Host Measure Interval, select the button to the right of the "Interval:" text. The numerical keypad will appear allowing a new number to be entered. See numerical keypad description under Zero Time on page 36 for more details.

Press the "Back" button to return to the Settings 3 Menu.

WiFi Measure Settings

These settings control the interval at which it is transmitted via WiFi. See Wireless Network Settings on page 113 for more details.

WiFi Measure Settings	
Format	The WiFi data is served as formatted web pages.
Interval (sec)	Determines the time interval, in seconds, in which data will be transmitted. A value of 0 disables automatic transmission of measurement data, but zero operations and Process operations will still be reported. The maximum value is 3600 seconds (1 hour). Default is 1 second.
Back Button	Returns to the Settings 3 Menu.

WiFi Measure Interval

To change the WiFi Measure Interval, select the button to the right of the "Interval:" text. The numerical keypad will appear, allowing a new number to be entered. See numerical keypad description under Zero Time on page 36 for more details.

Press the "Back" button to return to the Settings 3 Menu.

Memory Measure Settings

These settings control the format of measurement data, as well as the interval at which it is saved to the flash drive. See USB Flash Drive (Memory Stick) on page 89 for more details.

Memory Measure Settings	
Format	Determines the measure data format. All data formats are available (M1-M6). The default is M3. See the Measure Format Settings Table on page 93 for a detailed description of each format.
Interval	Determines the time interval, in seconds, in which data will be transmitted. A value of 0 disables automatic transmission of measurement data, but zero operations and Process operations will still be reported. The maximum value is 3600 seconds (1 hour). Default is 1 second.
Back	Returns to the Settings 3 Menu.

Memory Measure Format

To change the Memory Measure Format, select the button to the right of the "Format:" text. The Measure Format Settings screen will be displayed, with the current selection indicated. See Measure Format Settings Table on page 93 for more details.

Memory Measure Interval

To change the Memory Measure Interval, select the button to the right of the "Interval:" text. The numerical keypad will appear allowing a new number to be entered. See numerical keypad description under Zero Time on page 36 for more details.

Press the "Back" button to return to the Settings 3 Menu.

Host Port

This function allows the user to change/view the settings of the port connection used by the EGM-5. This parameter sets the port connection to either USB or WiFi. Refer to the Digital Communication Protocols and Software on page 96 for more information on this topic.
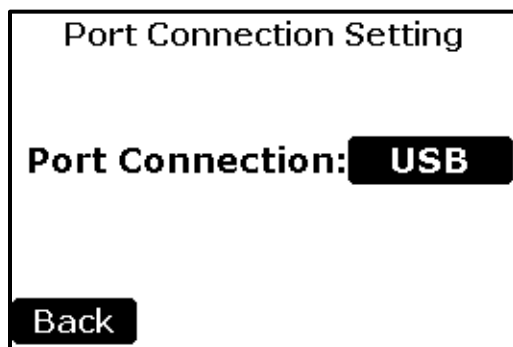
Port Connection Settings	
Port Connection	Sets the Port Connection to USB or WiFi. The default Port Connection setting is USB.
Back	Returns to the Settings 3 Menu.

Port Connection

To change the Port Connection value, select the button to the right of the "Port Connection:" text. The Port Connection settings will be displayed, with the current selection indicated.

Press the desired setting and then the Back button. The Port Connection Setting screen will return with the updated Port Connection value in the button text.

Press the "Back" button to return to the Settings 3 Menu.

Reset WiFi

This function allows the user to initialize the onboard WiFi device to factory default settings, if the WiFi option is installed.

Reset WiFi	
Yes	Starts the initialization process to restore WiFi configuration to factory defaults.
No	Returns to Settings 3 Menu without performing initialization.

WiFi Power

This function allows the user to turn WiFi power on or off.
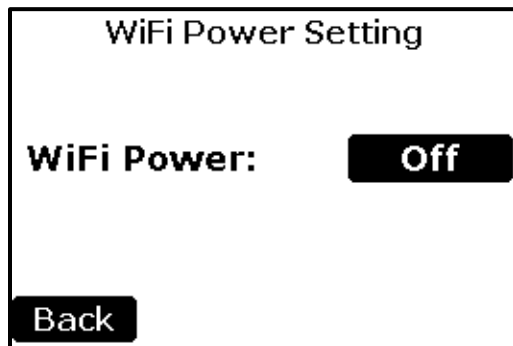
WiFi Power Setting	
WiFi Power	Enables (On) or disables (Off) the WiFi device. Default is Off.
Back	Returns to the Settings 3 Menu.

WiFi Power Setting

To change the WiFi Power value, select the button to the right of the "WiFi Power:" text. The WiFi Power settings will be display, with the current selection indicated.
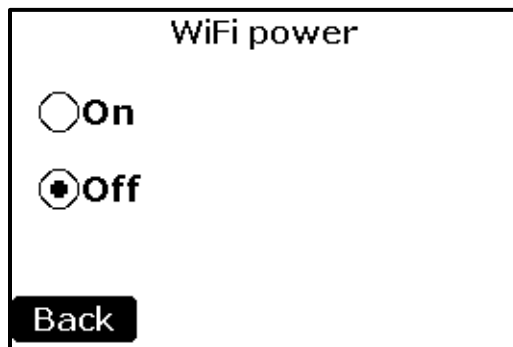
Press the desired setting and then the Back button. The WiFi Power screen will return with the updated WiFi Power value in the button text.

Press the "Back" button to return to the Settings 3 Menu.

Settings 4 Menu

This menu contains a number of settings for the EGM-5 including the Set Clock, Defaults, and Ship Mode settings.
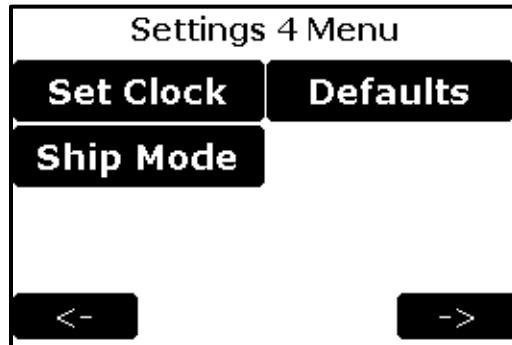
Settings 4 Menu	
Set Clock	Set/Check the system clock (date and time).
Defaults	Initializes EGM-5 back to factory default settings.
Ship Mode	Sets the EGM-5 to ship mode.
Main	Returns to the Main Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Returns to the Settings 1 Menu.

Set Clock

This function allows the user to change/view the EGM-5 real time clock.
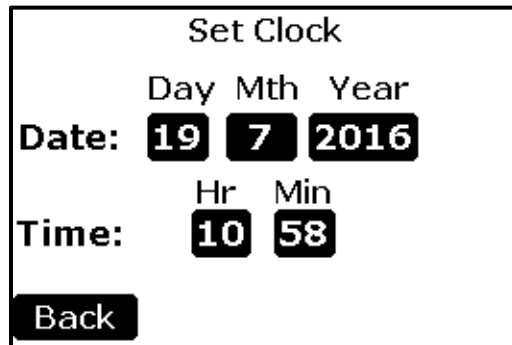
The date is displayed as day/month/year and the time is display on a 24-hour format. Selecting one of the buttons will cause the numerical keypad to appear, which will allow a new number to be entered.

Clock	
Day	Sets the current day of the month (1-31).
Mth	Sets the current month of the year (-12).
Year	Sets the current year (20XX).
Hr	Sets the current hour (0-23) (24 hour format).
Min	Sets the current minute (0-59).
Back	Returns to the Settings 4 Menu.

Press the "Back" button to return to the Settings 4 Menu.

Defaults

This function allows the user to initialize the EGM-5 to its factory default values. This feature may be needed to correct an erroneous calibration, or to simply undo undesirable configuration changes.

Defaults	
Yes	Resets EGM-5 to original factory settings then returns to Settings 4 Menu. This function allows the user to initialize the WMA-5 to its factory default values. This feature may be needed to correct an erroneous calibration, or to simply undo undesirable configuration changes.
No	Cancels the initialization process and returns to Setting 4 Menu.
Status Box	Any information or error messages are displayed here.

After initialization is complete, the EGM-5 system settings will be restored to the predefined factory defaults. Refer to the Get/Set Parameter Values Table on page 106 for more details.

Ship Mode

This function allows the user to put the EGM-5 into ship mode. The EGM-5 will not respond to presses of the On/Off button. This mode ensures that the unit is not inadvertently powered on during shipment. In order to take it out of ship mode, the EGM-5 needs to be connected to the power supply/charger provided with the instrument.

Ship Mode	
Yes	Sets the EGM-5 into ship mode. We recommend putting the EGM-5 into ship mode when transporting/shipping the instrument to avoid accidental power up.
No	Cancels out and the EGM-5 does not go into ship mode. Display returns to Setting 4 Menu.

Important Note

In order to get the EGM-5 out of "Ship Mode" you must first connect the power supply/charger to the EXT POWER jack before turning the instrument on. If you do not have the power supply/charger connected you will not be able to power up the instrument.

Processes

This menu handles the various processes of the EGM-5.
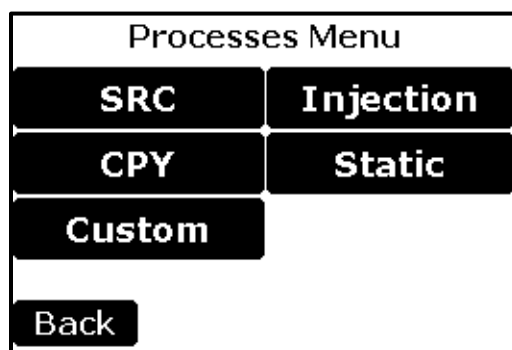
Processes Menu	
SRC	Starts the Soil Respiration Chamber (SRC) process.
CPY	Starts the Canopy Assimilation Chamber (CPY) process.
Custom	Starts the Custom process (for use with customer's own chambers).
Injection	Starts the Injection process using the "Sample Injection Kit" from PP Systems.
Static	Starts the Static process.
Main	Returns to the Main Menu.
Status Box	Any information or error messages are displayed here.

SRC (Soil Respiration Chamber) Process

This process is used in conjunction with our SRC-2 Soil Respiration Chamber for measurement of closed-system soil CO_2 efflux. In the SRC process, the respiration rate (g m^{-2} hr^{-1}) is calculated by measuring the rate of change (increase) in the chamber CO_2 concentration over a period of time. The EGM-5 calculates both a linear fit and a quadratic fit to the measured data. The data is checked in the quadratic fit to determine if the data is linear.

While the EGM-5 is in the SRC measuring mode, additional data is added to the output data string: change in CO_2 (dC), process time (dT), Linear respiration rate (L), and Quadratic respiration rate (Q).

SRC – Start Process (Step 1)

The first screen asks the user to confirm that they would like to start the SRC process.

```
 SRC - Start Process

 Would you like to start the SRC
 process or go back?



 Back        Status Box          →
```

SRC – Start Process Menu	
Back	Returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Confirms and starts the SRC process by displaying the SRC –Volume and Area Settings screen (Step 2).

SRC – Volume and Area Settings (Step 2)

The volume and area settings are defined in this screen.

```
 SRC - V and A Settings        Def

    Volume (ml):        1171

    Area (cm2):          78

    Volume/Area Ratio:   15

 Stop       Status Box          →
```

Important Note. The above values are based on the default volume of the SRC-2 Soil Respiration Chamber only. You must remember to account for any volume changes for proper calculation of rates. If using collars, please make sure that you adjust the volume accordingly.

SRC – Volume and Area Settings Menu

Def	Sets the volume and area values back to the defaults.
Volume (ml)	Sets the volume of the system. Entries between 1,000 and 2,000 ml are permitted. Default is 1171 ml.
Area (cm^2)	Sets the surface area of the chamber. Entries between 50 and 100 cm^2 are permitted. The default value is 78 cm^2.
Volume/Area Ratio	This value is automatically updated when there is a change to either the Volume or Area values.
Stop	Stops the SRC process and returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to SRC – Termination Settings menu (Step 3).

SRC – Termination Settings (Step 3)

The Termination settings (DT, DC) as well as delay are defined in this screen. These settings define the end conditions for the SRC process. Each new measurement session will begin after the specified Delay, and will terminate when either the elapsed time reaches the DT value, or when the total change in CO_2 exceeds a specified threshold (DC), whichever occurs first.

```
┌─────────────────────────────────────────────┐
│  SRC - Termination Settings                   │
│                                               │
│   DT (seconds):        [   120   ]            │
│                                               │
│   DC (ppm):            [   50    ]            │
│                                               │
│   Delay (seconds):     [    9    ]            │
│                                               │
│  [Stop] ┊    Status Box    ┊      [ → ]       │
└─────────────────────────────────────────────┘
```

SRC – Termination Settings Menu

DT (seconds)	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. Valid entries range between 10 - 300 seconds.
DC (ppm)	Maximum positive change in CO_2 concentration (ppm) allowed in a given session. If total change exceeds this value, the session will end. Valid entries are between 1 - 1,000 ppm.
Delay (seconds)	The amount of time the instrument waits at the start of each session before it starts calculating respiration. Valid entries are between 5 – 150 seconds.
Stop	Stops the SRC process and returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to SRC – Other Settings menu (Step 4).

SRC – Other Settings (Step 4)

The plot number is defined in this screen to allow the user to reference different sampling plots.

```
SRC - Other Settings


   Plot Number:          1




Stop        Status Box         →
```

SRC – Other Settings Menu	
Plot Number	Change/View plot number. Range: 1–1000.
Stop	Stops the SRC process and returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to SRC – Prepare Chamber screen (Step 5).

SRC Step 5

This screen instructs the user to prepare the chamber.

```
SRC - Prep Chamber        24

Hold chamber in air for flushing.



     CO2 1000

Stop        Status Box
```

SRC – Prepare Chamber Menu (Step 5)	
CO2	Current measurement of CO_2 concentration (ppm).
24	Countdown in seconds, from 25 to 0.
Stop	Stops the SRC process and returns to SRC – Other Settings menu (Step 4).
Status Box	Any information or error messages are displayed here.

At this stage, the SRC chamber should be held in the air to allow it to flush out prior to placing it on the soil. During the flushing the internal fan of the SRC is sped up to help flush. The number at the top right of the screen (24 in this case) is the countdown. CO_2 concentration is displayed during this step. When completed, SRC Step 6 will be displayed.

SRC – Start Measuring (Step 6)

This screen informs the user to place the chamber on the soil to commence measurement.

```
┌─────────────────────────────────────────┐
│  SRC - Start Measuring            5      │
│                                          │
│  Place chamber on soil.                  │
│                                          │
│                                          │
│         CO2  1000                        │
│                                          │
│ ┌──────┐ ┌─────────────────────────────┐│
│ │ Stop │ │        Status Box           ││
│ └──────┘ └─────────────────────────────┘│
└─────────────────────────────────────────┘
```
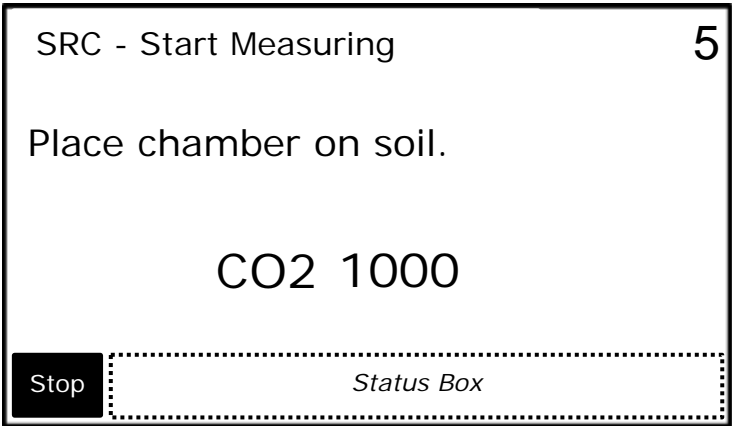
SRC – Start Measuring Menu	
CO2	Current measurement of CO_2 concentration (ppm).
5	Countdown in seconds, from 10 to 0.
Stop	Stops the SRC process and returns to SRC – Other Settings menu (Step 4).
Status Box	Any information or error messages are displayed here.

At this stage, the SRC chamber should be placed on the soil. The internal fan is set to a low speed to provide an even concentration of CO_2. The number at the top right of the screen (5 in this case) is the countdown. CO_2 concentration is displayed during this step. When completed, the Data Plot Screen will be displayed.

Data Plot Screen (Step 7)

This screen displays present values and a graphical representation of the data gathered during the current session.

```
┌─────────────────────────────────────────┐
│ ♥ 75%                 C: 603      CAL    │
│ dC  26                                   │
│ dT  24                                   │
│ L  1.91                                  │
│ Q -0.77                                  │
│ Plot  1                                  │
│          maxDC 50    maxDT 120           │
│ ┌──────┐ ┌─────────────────┐ ┌────────┐ │
│ │Abort │ │   Status Box    │ │  New   │ │
│ └──────┘ └─────────────────┘ └────────┘ │
└─────────────────────────────────────────┘
```

SRC Data Plot Screen	
♥ (Heartbeat)	Pulses on and off to indicate that the system is powered on (power status).
75%	Percentage of battery life remaining (%).
C: 603	Current measurement of CO_2 Concentration (ppm).
Delay/CAL/END	Delay is the countdown in seconds from x to 0, where x is the Delay value specified in SRC – Termination Settings (Step 3). CAL is the active CO_2 concentration calculating phase. END indicates calculations have been terminated.
dC	The difference in CO_2 concentration (ppm) from time = 0 seconds.
dT	Elapsed time (seconds) for the current session (i.e., change in time).
L	Linear respiration rate (g m^{-2} hr^{-1}).
Q	Quadratic respiration rate (g m^{-2} hr^{-1}).
Plot	Plot number defined by user in SRC – Other Settings (Step 4).
X-axis	Time (1 second interval)
Y-axis	dC (change in CO_2 concentration)(ppm)
maxDC	Maximum positive change in CO_2 concentration (ppm) allowed in a given session. This value is defined in SRC – Termination Settings (Step 3).
maxDT	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. This value is defined in SRC – Termination Settings (Step 3).
Abort	Stops the SRC process and returns to SRC – Other Settings (Step 4). Only the individual CO_2 measurements are saved to the USB flash drive. Process data is discarded.
Status Box	Any information or error messages are displayed here.
New	Stops the SRC process and returns to SRC – Other Settings (Step 4). Results are saved to the USB flash drive.

The measurement sequence will terminate when the maxDC or maxDT is reached. If maxDT is reached first, the message "Time limit" will appear in the status box. If maxDC is reached first, the message "CO2 limit" will appear in the status box.

For more information on the theory and calculation of soil respiration/canopy assimilation, please refer to Appendix 1. Soil CO_2 Efflux and Net Canopy CO_2 Flux on page 124.

CPY (Canopy Assimilation Chamber) Process

This process is used in conjunction with our CPY-5 Canopy Assimilation Chamber for measurement of closed-system net canopy CO_2 flux. In the CPY process, the assimilation rate (µmol m^{-2} s^{-1}) is calculated by measuring the rate of change (decrease) in the chamber CO_2 concentration. The EGM-5 calculates both a linear fit and a quadratic fit to the measured data. The data is checked in the quadratic fit to determine if the data is linear.

While the EGM-5 is in the CPY measurement mode, additional data is added to the output data string: change in CO_2 (dC), process time (dT), Linear respiration rate (L), and Quadratic respiration rate (Q).

CPY – Start Process (Step 1)

The first screen asks the user to confirm that they would like to start the CPY process.

```
CPY - Start Process

Would you like to start the CPY
process or go back?



  Back          Status Box            →
```

CPY – Start Process Menu	
Back	Returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Confirms and starts the CPY process by displaying the CPY – Volume and Area Settings menu (Step 2).

CPY – Volume and Area Settings (Step 2)

The volume and area settings are defined in this screen.

```
CPY - Vol and A Settings               Def

   Volume (ml):        2427

   Area (cm2):          167

   Volume/Area Ratio:   14.5

  Stop          Status Box            →
```

Important Note. The above values are based on the default volume for the CPY-5 Canopy Assimilation Chamber only. You must remember to account for any volume changes in order for the instrument to properly calculate assimilation rates. If using collars, please make sure that you adjust the volume accordingly.

CPY – Volume and Area Settings Menu

Def	Sets the volume and area values back to the defaults.
Volume (ml)	Sets the volume of the system. Entries between 1,000 and 5,000 ml are permitted. Default is 2427 ml.
Area (cm²)	Sets the surface area of the chamber in cm^2. Entries between 150 and 200 cm^2 are permitted. The default value is 167 cm^2.
Volume/Area Ratio	This value is automatically updated when there is a change to either the Volume or Area values.
Stop	Stops the CPY process and returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to CPY – Termination Settings menu (Step 3).

CPY – Termination Settings (Step 3)

The Termination Settings (DT, DC) as well as Delay are defined in this screen.

CPY – Termination Settings Menu

DT (seconds)	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. Valid entries range between 10 - 300 seconds.
DC (ppm)	Maximum negative change in CO_2 concentration (ppm) allowed in a given session. If total change exceeds this value the session will end. Valid entries are between 1 - 1,000 ppm.
Delay (seconds)	The amount of time the instrument waits at the start of each session before it starts calculating respiration. Valid entries are between 5 – 150 seconds.
Stop	Stops the CPY process and returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to CPY – Other Settings Menu (Step 4).

CPY – Other Settings (Step 4)

The plot number is defined in this screen.

```
CPY - Other Settings


   Plot Number:          1



Stop      Status Box        →
```

CPY – Other Settings Menu

Plot Number	Change/View plot number. Range: 1–1000.
Stop	Stops the CPY process and returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to CPY – Prepare Chamber menu (Step 5).

CPY – Prepare Chamber (Step 5)

This screen instructs the user to prepare the chamber.

```
CPY - Prep Chamber        24

Hold chamber in air for flushing.



      CO2 1000

Stop        Status Box
```

CPY – Prepare Chamber Menu

CO2 (ppm)	Current measurement of CO_2 concentration (ppm).
24	Countdown in seconds, from 25 to 0.
Stop	Stops the CPY process and returns to CPY Step 4.
Status Box	Any information or error messages are displayed here.

At this stage, the CPY chamber should be held in the air to allow it to flush out prior to placing it on the soil. During this step, the internal fan of the CPY is sped up to help flush the chamber. The number at the top right of the screen (24 in this case) is the countdown. CO_2 concentration is displayed during this step. When completed, the process will proceed to the CPY – Start Measuring screen (Step 6).

CPY – Start Measuring (Step 6)

This screen instructs the user to place the chamber on the soil to commence measuring.

```
CPY - Start Measuring              5


Place chamber on soil.



       CO2  1000


┌──────────┐ ┌─────────────────────┐
│   Stop   │ │      Status Box      │
└──────────┘ └─────────────────────┘
```

CPY – Start Measuring Menu	
CO2 (ppm)	Current measurement of CO_2 concentration (ppm).
5	Countdown in seconds, from 10 to 0.
Stop	Stops the CPY process and returns to CPY – Other Settings (Step 4).
Status Box	Any information or error messages are displayed here.

At this stage, the CPY chamber should be placed on the soil. The internal fan is set to a low speed to provide an even concentration of CO_2. The number at the top right of the screen (5 in this case) is the countdown. CO_2 concentration is displayed during this step. When completed, CPY Step 7 will be displayed.

CPY Data Plot Screen (Step 7)

This screen displays present values and a graphical representation of the data gathered during the current session.

```
♥ 75%                        C: 603      CAL
dC  26
dT  24
L  1.91
Q -0.77
Plot  1
         maxDC 25      maxDT 30
┌───────┐ ┌──────────────────┐ ┌───────┐
│ Abort │ │    Status Box     │ │  New  │
└───────┘ └──────────────────┘ └───────┘
```

CPY Data Plot Screen	
♥ (Heartbeat)	Pulses on and off to indicate that the system is powered on (power status).
75%	Percentage of battery life remaining.
C: 603	Current measurement of CO_2 Concentration (ppm).
Delay/CAL/END	Delay is the countdown in seconds from x to 0, where x is the Delay value specified in CPY – Termination Settings (Step 3). CAL is the active CO_2 concentration calculating phase. END indicates calculations have been terminated.
dC	The current difference in CO_2 concentration (ppm) from time = 0 seconds. Normally in assimilation, CO_2 concentration is decreasing, but for display purposes the negative values are inverted.
dT	Elapsed time (seconds) for the current session (i.e., change in time).
L	Linear assimilation rate ($\mu mol\ m^{-2}\ s^{-1}$).
Q	Quadratic assimilation rate ($\mu mol\ m^{-2}\ s^{-1}$).
Plot	Plot number defined by user in CPY – Other Settings (Step 4).
X-axis	Time (1 second interval)
Y-axis	dC (change in CO_2 concentration)(ppm)
maxDC	Maximum negative change in CO_2 concentration (ppm) allowed in a given session. This value is defined in CPY – Termination Settings (Step 3).
maxDT	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. This value is defined in CPY – Termination Settings (Step 3).
Abort	Stops the CPY process and returns to CPY – Other Settings (Step 4). Only the individual CO2 measurements are saved to the USB flash drive. Process data is discarded.
Status Box	Any information or error messages are displayed here.
New	Stops the CPY process and returns to CPY – Other Settings (Step 4). Results are saved to the USB flash drive.

The measurement sequence will terminate when the maxDC or maxDT is reached. If maxDT is reached first, the message "Time limit" will appear in the status box. If maxDC is reached first, the message "CO2 limit" will appear in the status box.

For more information on the theory and calculation of soil respiration/canopy assimilation, please refer to Appendix 1. Soil CO_2 Efflux and Net Canopy CO_2 Flux on page 124.

Custom Process

This process is available for users that want to use their own custom chambers with the EGM-5. Since it is assumed that you are using your own chambers there are no "defaults" built into the system. It is your responsibility to make sure that you enter the appropriate values where required in order to ensure proper calculations.

Custom – Start Process (Step 1)

The first screen asks the user to confirm that they would like to start the Custom process.

```
 Custom - Start Process

 Would you like to start the custom
 process or go back?



 [Back]          Status Box          [→]
```

Custom – Start Process Menu	
Back	Returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Confirms and starts the Custom process by displaying the Custom – Volume and Area Settings menu (Step 2).

Custom – Volume and Area Settings (Step 2)

The volume and area settings are defined in this screen.

```
 Custom - V and A Settings

    Volume (ml):        2000

    Area (cm2):         100

    Volume/Area Ratio:  20

 [Stop]        Status Box        [→]
```

Important Note. You must remember to account for any volume changes in order for the instrument to properly calculate assimilation rates. If using collars, please make sure that you adjust the volume accordingly.

Custom Step 2 Menu	
Volume (ml)	Sets the volume of the system. Entries between 10 and 100,000 ml are permitted.
Area (cm^2)	Sets the surface area of the chamber in cm^2. Entries between 1 and 10,000 cm^2 are permitted.
Volume/Area Ratio	This value is automatically updated when there is a change to either the Volume or Area values.
Stop	Stops the Custom process and returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to the Custom – Termination Settings menu (Step 3).

Custom – Termination Settings (Step 3)

The Termination settings (DT, DC) and Delay are defined in this screen.

Custom - Termination Settings

DT (seconds): 120

DC (ppm): 50

Delay (seconds): 9

Stop   Status Box   →

Custom – Termination Settings Menu	
DT (seconds)	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. Valid entries range between 10 - 300 seconds.
DC (ppm)	Maximum change in CO_2 concentration (ppm) allowed in a given session. If total change exceeds this value the session will end. Valid entries are between 1 - 1,000 ppm.
Delay (seconds)	The amount of time the instrument waits at the start of each session before it starts calculating respiration. Valid entries are between 5 – 150 seconds.
Stop	Stops the Custom process and returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to the Custom – Other Settings menu (Step 4).

Custom – Other Settings (Step 4)

The plot number is defined in this screen.

```
Custom - Other Settings


  Plot Number:        1


  Tair (°C):          25


 Stop      Status Box        →
```

Custom – Other Settings Menu	
Plot Number	Change/View plot number. Range: 1–1000.
Tair (°C)	Air temperature inside chamber (ºC).
Stop	Stops the Custom process and returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Continues to the Custom – Prepare Chamber screen (Step 5).

Custom – Prepare Chamber (Step 5)

This screen prompts the user to prepare the chamber.

```
Custom - Prep Chamber

Flush chamber.



     CO2 1000

 Stop     Status Box        Start
```

Custom – Prepare Chamber Menu	
CO2 (ppm)	CO_2 concentration.
Stop	Stops the Custom process and returns to the Custom – Other Settings menu (Step 4).
Start	Continues to the Custom – Start Measuring screen (Step 6). Note: It is up to the user to determine the amount of time required to flush a custom chamber.
Status Box	Any information or error messages are displayed here.

At this stage, the Custom probe should be held in the air to allow it to flush out prior to placing it on the soil. CO_2 concentration is displayed during this step. Unlike the SRC and CPY Processes, there is no countdown for flushing the chamber; it is up to the user to determine the amount of time required to flush a custom chamber. Once the chamber has been adequately flushed, pressing the Start button will allow the process to continue to the Custom – Start Measuring screen (Step 6)

Custom – Start Measuring (Step 6)

This screen instructs the user to place the chamber on the soil to commence measuring.

```
 Custom - Start Measuring        5


 Place chamber on soil.



          CO2  1000


 ┌──────────┐ ┌·····························┐
 │   Stop   │ :         Status Box        :
 └──────────┘ └···························  ┘
```

Custom – Start Measuring Menu	
CO2 (ppm)	CO_2 concentration.
5	Countdown in seconds, from 10 to 0.
Stop	Stops the Custom process and returns to Custom Step 4.
Status Box	Any information or error messages are displayed here.

At this stage, the Custom probe should be placed on the soil. The number at the top right of the screen (5 in this case) is the count down from 10-0 seconds. CO_2 concentration is displayed during this step. When completed, the Custom Data Plot screen (Step 7) will be displayed.

Custom Data Plot Screen (Step 7)

This screen displays present values and a graphical representation of the data gathered during the current session.

```
♥ 75%                     C: 603       CAL
dC  26
dT  24
L  1.91
Q -0.77
Plot  1
        maxDC 25       maxDT 30
┌────────┐┌························┐┌────────┐
│ Abort  ││      Status Box       ││  New   │
└────────┘└························┘└────────┘
```
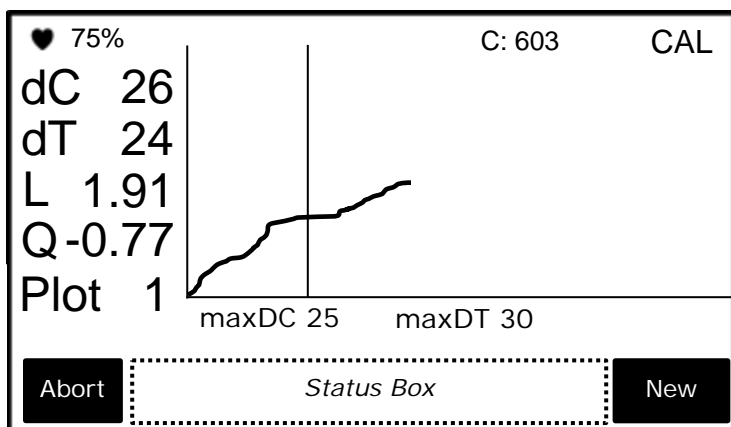
Custom Data Plot Menu	
♥ (Heartbeat)	Pulses on and off to indicate that the system is powered on (power status).
75%	Percentage of battery life remaining.
C: 603	Current measurement of CO_2 Concentration (ppm).
Delay/CAL/END	Delay is the countdown in seconds from x to 0, where x is the Delay value specified in Custom – Termination Settings (Step 3). CAL is the active CO_2 concentration calculating phase. END indicates calculations have been terminated.
dC	The current difference in CO_2 concentration (ppm) from time = 0 seconds.
dT	Elapsed time (seconds) for the current session (i.e., change in time).
L	Linear respiration rate (g m^{-2} $hour^{-1}$).
Q	Quadratic respiration rate (g m^{-2} $hour^{-1}$).
Plot	Plot number defined by user in Custom – Other Settings (Step 4).
X-axis	Time (1 second interval)
Y-axis	dC (change in CO_2 concentration)(ppm)
maxDC	Maximum negative change in CO_2 concentration (ppm) allowed in a given session. This value is defined in Custom – Termination Settings (Step 3).
maxDT	Maximum time for which changes in the chamber CO_2 concentration are monitored in a given session. This value is defined in Custom – Termination Settings (Step 3).
Abort Button	Stops the Custom process and returns to Custom – Other Settings (Step 4). Only the individual CO2 measurements are saved to the USB flash drive. Process data is discarded.
Status Box	Any information or error messages are displayed here.
New Button	Stops the Custom process and returns to Custom – Other Settings (Step 4). Results are saved to the USB flash drive.

Injection Process

The injection process is a technique used to measure the concentrations of small samples of gas, usually collected in sampling jars and transferred to the EGM-5 with a syringe. The injection process is an improvement over static sampling and yields more reliable and consistent results.

Measurement Principle

The concentration of CO_2 in a gas sample is calculated by injecting the sample into a fixed flow of gas with a known CO_2 concentration (the baseline CO_2 level) and integrating the resulting CO_2 measurements until they return to baseline. This is similar to the Pulse Tracer Gas Technique used for HVAC duct flow to infer the unknown flow rate by measuring the concentration of a known mass of tracer gas injected into the duct over time. In our case, the gas flow rate F is known, the syringe volume V is known, but the sample (or tracer gas) concentration is unknown.

The concentration in the syringe is calculated as:

$$CO_{2\,INT} = \int C(t)dt \cdot \frac{F}{V} = \sum (CO_{2\_m} - CO_{2\_b}) \cdot \frac{\Delta t}{60} \cdot \frac{F}{V}$$

Where

  $CO_{2\,INT}$ (ppm) = calculated CO_2 concentration inside syringe ("integrated" CO_2)

  CO_{2_b} (ppm) = baseline CO_2 readings before the measurement phase (averaged over 10 readings)

  CO_{2_m} (ppm) = CO_2 readings during the measurement phase

  Δt (s) = sample interval, typically 1 second

  F (ml min^{-1}) = flow rate

  V (ml) = syringe volume

The process consists of two phases: Baseline Phase and Measurement Phase. The Baseline Phase establishes a baseline measurement of CO_2 concentration by passing CO_2-free gas through the EGM-5 and calculating the average concentration over 10 measurements at a 1-second interval. Upon completion of the Baseline Phase, the instrument will enter the Measurement Phase. In this phase the sample is slowly injected, and the measured CO_2 concentrations are integrated over the duration of the Measurement Phase. Any gas with a known, constant CO_2 concentration can be used as a baseline, but a gas with zero CO_2 concentration can be readily produced with an absorber column filled with soda lime.

Sample Injection Kit (Part No. ACS037)

PP Systems offers a Sample Injection Kit (Part No. ACS037), which includes a fully assembled and leak-tested injection port with 4 spare septa, as well as an absorber column to establish a zero baseline.

The syringe is user supplied (not included with the kit) and the soda lime is not included with this part but it is included with the EGM-5 as standard.

The injection port includes a 9mm low-bleed septum that can withstand up to 50 injections (per the manufacturer's specification). For best results, we recommend changing the septum every 25 injections.

The septum has a guide hole and accommodates syringes up to 22 gauge, but we recommend at least 18 gauge for best results. The syringe is not included in the kit and must be provided by the user. The injection technique is relatively insensitive to the volume of the syringe, but it should be at least a size where you could comfortably inject gas for at least 3 seconds continuously. For this reason alone, syringes with a volume of at least 10 ml (e.g. 10- and 25-ml syringes) are recommended. The injection rate should not exceed 3 ml/s, due to the risk of over-pressurizing the IRGA and causing damage to the instrument. We recommend glass syringes if available (e.g. typical GC syringes), but plastic (polypropylene) syringes will work as well.

The injection process works best for samples with concentrations greater than 100 ppm. The process will work at lower concentrations, but percent error will be significantly larger.

Injection – Start Process (Step 1)

The first screen asks the user to confirm that they would like to start the Injection process.

To begin a sample injection measurement, first fill the absorber column of the Sample Injection Kit with fresh soda lime and ensure it is oriented vertically throughout the process. Connect the open end of the kit to the **GAS IN** port on the back of the EGM-5.
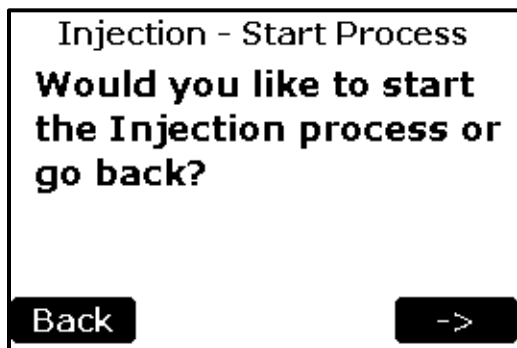
Injection – Start Process Menu	
Back Button	Returns to the Processes Menu.
Right Arrow Button	Confirms and starts the Injection process by displaying the Injection – Settings screen (Step 2).

Injection – Settings (Step 2)

The syringe volume and correction factor settings are defined in this screen.

```
         Injection - Settings

  Syringe Vol(ml):      10.0

  Correction Factor:    1.00

  Stop                    ->
```

Injection – Settings Menu	
Syringe Volume(ml) Button	Volume of injection syringe. Valid entry range is between 1.0 – 1,000.0 ml.
Correction Factor Button	This user defined factor can be used to scale calculated gas concentrations to make them match a known reference gas standard. Range: 0.50 – 2.00.
Stop Button	Stops the Custom process and returns to the Processes Menu.
Right Arrow Button	Continues the Injection process to Injection Step 3 screen.

Injection – Sample Setting (Step 3)

The sample number is defined in this screen. Once the Start button is pressed, the Injection process will begin. Before you press Start, take your syringe sample (e.g., from a chamber or airbag) if you have not done so already. We recommend that you draw more gas from your sample source than required, and then squeeze out excess. For example, for a 10 ml sample you should draw at least 11 ml into your syringe, and then slowly push the plunger to the 10 ml mark.

```
    Injection - Sample Setting

  Sample Number:       1

  Have syringe sample ready
  and press Start.

  Stop                 Start
```
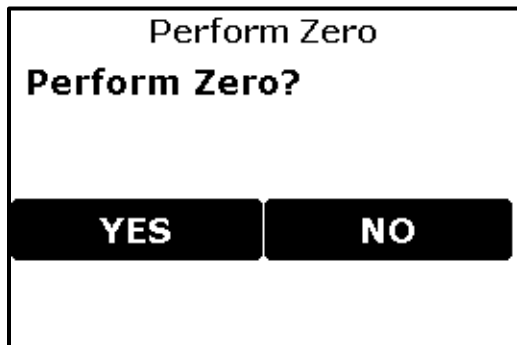
Injection – Sample Setting Menu	
Sample Number Button	Sample number of measurement.
Stop Button	Stops the Custom process and returns to the Processes Menu.
Start Button	Starts the Injection Process and displays the Injection Baseline Phase screen (Step 4).

Injection – Zero (Step 4)

The next screen prompts the user whether to perform a zero or not. Since an autozero occurring during an injection measurement would disrupt the process, normal timed zeros are disabled. It is recommended that a zero be performed at the start of each measurement sequence. But it is not required to perform one every single measurement.
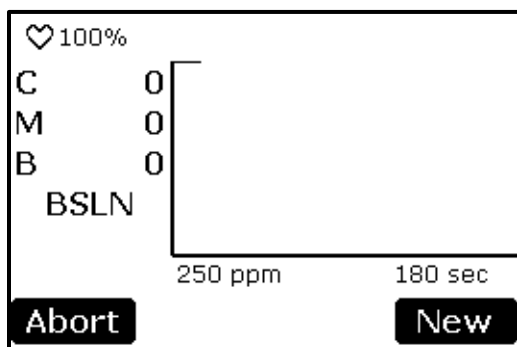
Perform Zero	
Yes Button	Does a Zero then proceeds to Measuring screen (Step 5).
No Button	Proceeds to Measuring screen (Step 5).

Injection Step 5 – Baseline Phase

This is the Baseline Phase. For the first 10 seconds, the EGM-5 will record the baseline reading, which is the CO_2 concentration of the air before the sample is injected (typically 0 ppm). After 10 seconds the Injection Phase begins. We recommend inserting the needle from your syringe into the septum at this point in time to avoid contamination of the sample about to be injected into the EGM-5.

Injection Baseline Phase Menu	
♥ **(Heartbeat)**	Pulses on and off to indicate that the system is powered on (power status).
100%	Percentage of battery life remaining.
C	Current CO_2 concentration in tubing (ppm).
M	Calculated CO_2 concentration inside syringe (ppm).
B	Average baseline of CO_2 concentration (ppm).
BSLN	Indicates that the process is in the Baseline phase for the first 10 readings.
X-axis	Time (seconds). It is fixed at 180 seconds.
Y-axis	CO_2 concentration in tubing (ppm).
250 ppm	CO_2 concentration maximum. This is set to be ¼ of the Max CO_2 value for the Graph setting and can be modified under Main > Settings > Settings 2 > Graph. (For example, when Max CO2 is set to 1000 ppm, this graph shows 250 ppm.)
Abort Button	Stops the Injection process and returns to Injection – Settings (Step 2). Process data is not saved to the USB flash drive.
New Button	Stops the Injection process and returns to Injection - Settings (Step 2). Injection Process results are saved to the USB flash drive.

If the baseline (B) does not drop to either 0 or a very small number (typically 1-3 ppm), then there is either a leak in the system, or the system has not adequately "zeroed". Try aborting the process, wait 2-3 minutes, and try again. If the problem persists, check the Injection setup for leaks and ensure that the absorber column is properly seated and contains fresh soda lime.

Injection Step 6 – Injection Phase

During the Injection Phase, the syringe should be slowly and steadily injected into the airstream through the septum. The injection rate should not exceed 3 ml/second to avoid over-pressurization of the system (in other words, it should take the user at least 3 seconds to inject a 10 ml syringe).
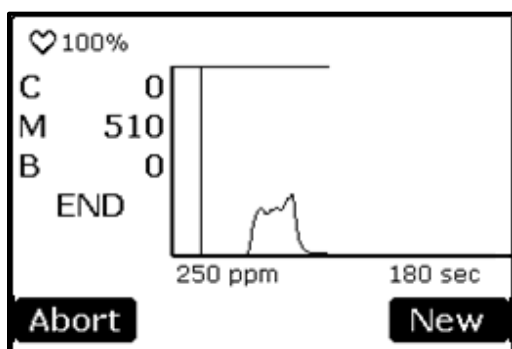
Injection Step 6 Menu	
♥ **(Heartbeat)**	Pulses on and off to indicate that the system is powered on (power status).
100%	Percentage of battery life remaining.
C	Current CO_2 concentration in tubing (ppm).
M	Calculated CO_2 concentration inside syringe (ppm).
B	Average baseline of CO_2 concentration (ppm).
INJT/END	INJT Indicates that the process is in the injection phase. END indicates CO_2 concentration calculations have been terminated.
X-axis	Time (seconds). It is fixed at 180 seconds.
Y-axis	CO_2 concentration in tubing (ppm).
250 ppm	CO_2 concentration maximum. This is set to be ¼ of the Max CO_2 value for the Graph setting and can be modified under Main > Settings > Settings 2 > Graph. (For example, when Max CO2 is set to 1000 ppm, this graph shows 250 ppm.)
Abort Button	Stops the Injection process and returns to the Injection Baseline menu (Step 4). Process results are not saved to the USB flash drive.
New Button	Stops the Injection process and returns to Injection Baseline menu (Step 4). Injection Process results are saved to the USB flash drive.

Typically during an injection, the first value will rise quickly and drop back to zero; correspondingly, the value of M will increase quickly as the value of C peaks and then plateaus at a constant value. Once C has dropped to 0 ppm (or a very low background value), wait 3-5 seconds to make sure M has stabilized and take note of the value. This value is also recorded on the USB memory stick, if a memory stick has been inserted.

Errors from injection measurements are typically larger than flow-through methods (larger errors could come from both instrumental and handling sources), so it is recommended that you measure the same sample multiple times and calculate an average whenever possible.

Static Process

If static sampling is selected, the user can inject samples directly into the sample cell through the port labelled **GAS OUT** rather than having the sample pumped through it. This is normally done using a syringe with 1/8" tubing on the end which can easily fit over the **GAS OUT** port on the EGM-5. For static measurements injected directly into the "Gas Out" port, we recommend a minimum sample volume of 5 ml.

Note: The system will still perform its regularly scheduled zeros even if a Static measurement is ongoing. A warning will be displayed 2 minutes before the zero and again 1 minute prior. The onboard pump will turn on during the zero. Upon completion of the zero the pump will again switch off.

The general procedure for taking a Static measurement is as follows:

1. Navigate to Main > Processes > Static.

2. Press the right arrow button to begin the Static Process.

3. A zero is automatically performed.

4. After the zero is completed (the sample pump is now off), the system is ready for a sample injection.

5. Inject your sample (minimum of 5 ml) directly into the **GAS OUT** port. We recommend a slow, steady injection rate of approximately 6 ml/second. Initially, the CO_2 concentration will be higher (due to pressure) and then will drop to the actual concentration and should remain stable. Once the reading stabilizes, take note of the value. This value is also recorded on the USB memory stick, if a memory stick has been inserted. To start a new measurement, press New. Remove the syringe from the **GAS OUT** port to allow the system to flush properly.

Static – Start Process (Step 1)

The first screen asks the user to confirm that they would like to start the Static process.

```
 Static - Start Process

 Would you like to start the Static
 process or go back?




 Back        Status Box        →
```

Static – Start Process Menu	
Back	Returns to the Processes Menu.
Status Box	Any information or error messages are displayed here.
Right Arrow	Confirms and starts the Static process by displaying the Static Data Plot screen (Step 2).

Static Data Plot (Step 2)

Upon entry to this screen, a zero will be performed.

```
 ♥ 75%                        Z

 C  531
 Pr1022


      1000 ppm      180 sec

 Abort      Z 24.0      New
```
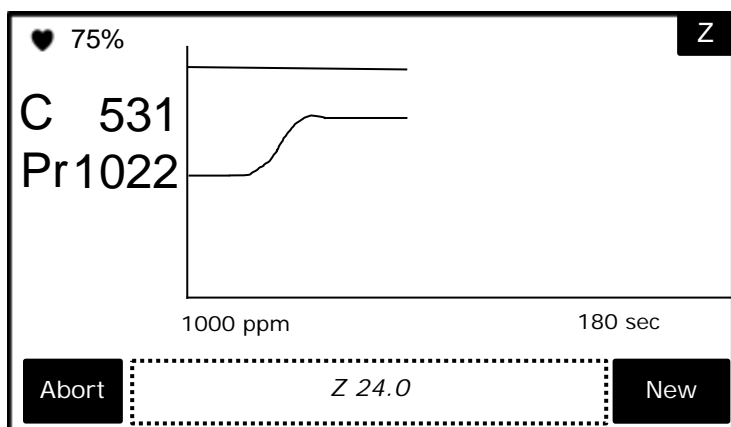
| Static Step 2 Menu	
♥ (Heartbeat)	Pulses on and off to indicate that the system is powered on (power status).
75%	Percentage of battery life remaining.
Z	Initiates a zero.
C	Current CO_2 concentration in the IRGA (ppm).
Pr	Atmospheric pressure (mb).
X-axis	Time, 1 second interval. It is fixed at 180 seconds.
Y-axis	CO_2 concentration in the IRGA (ppm).
1000 ppm	CO_2 concentration maximum. This is the same value as the Max CO_2 value for the Graph setting and can be modified under Main > Settings > Settings 2 > Graph.
Abort	Stops the Injection process and returns to the Processes Menu. Static Process results are not saved to the USB flash drive.
Status Box	Any information or error messages are displayed here.
New Button	Stops the current Static process and saves results to the USB flash drive. Clears graph to begin another Static process. No zero is performed.

Calibration

This menu handles the calibration of CO_2 IRGA, the O_2 Sensor and the Touch Screen.
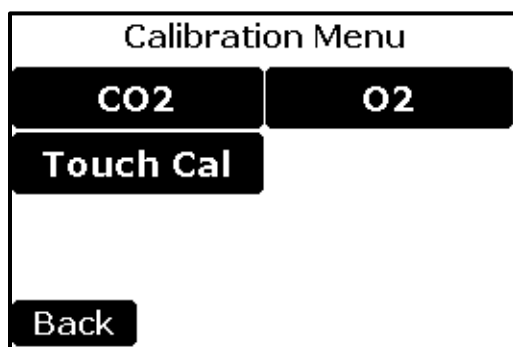
Calibration Menu	
CO2	Initiates CO_2 calibration.
O2	Initiates O_2 calibration.
Touch Cal	Calibrates the touch screen display.
Back Button	Returns to the Main Menu.
Status Box	Any information or error messages are displayed here.

CO2

This menu allows the user to recalibrate the CO2 gas analyzer. Before proceeding with an instrument recalibration, it is critical that:

- The absorber column is properly seated in its manifold
- The soda lime (CO_2 scrubber) is fresh.
- The EGM-5 has been on for at least 30 minutes.
- The Gas Out port is unobstructed.

```
                    Calibrate
       Enter value to begin.
       CO2 Conc (ppm)      650

        Actual CO2 (ppm) =  662
        CO2 Scale Factor = 1.000

        Stop
```

| Calibration	
CO2 Conc (ppm) Button	CO_2 concentration (ppm) of the calibration reference gas. Entering a value will begin the calibration process
Actual CO2	The current CO2 Reading based on the Scale Factor
CO2 Scale Factor	The current Scale Factor being used
Stop Button	Returns to the Calibration Menu.

Connecting Calibration Gas to the EGM-5

During calibration, the signal from the CO_2 detector is referenced against a gas of known CO_2 concentration. The EGM-5 calibration procedure uses two reference points:

1. Zero CO_2, generated from air that has been scrubbed of CO_2 through the soda lime in the absorber column.
2. Span (reference) gas, a user-provided gas with a known CO_2 concentration, typically from a very accurate (+/- 1%) certified source.

It is vital that both of these references are accurate. For greater accuracy, cylinder mixtures should be traceable to NIST (National Institute of Standards and Technology) standards. The zero gas will only be accurate if the soda lime in the absorber column is fresh.

Assuming that a calibration gas mixture is used to calibrate the EGM-5, follow these instructions:

1. To avoid excess pressure in the sample cell and possible damage to the analyzer, you must place a T-fitting between the reference gas source and the **GAS IN** port on the EGM-5. One end of the T-fitting should be left open in order to relieve excess pressure, as follows:
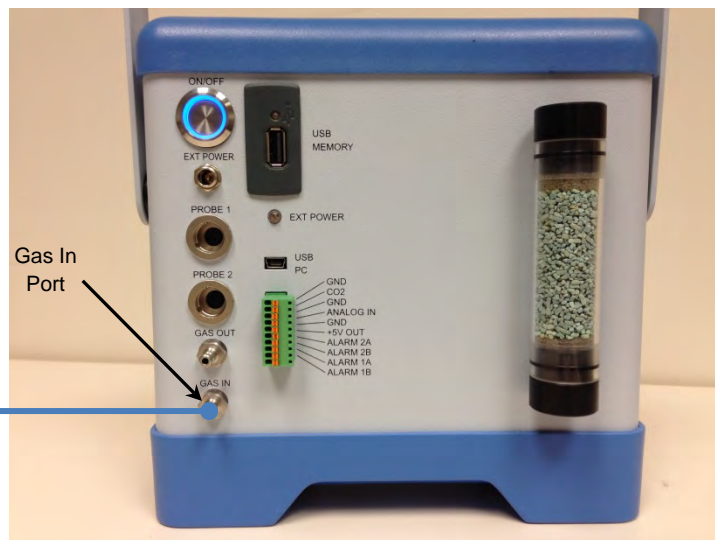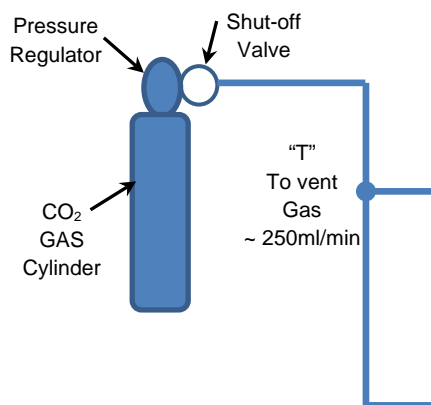
2. The pressure regulator on the reference source should be set to a very low pressure, such that the flow rate of excess gas from the open end of the T-fitting should be approximately 250 ml/min.

3. Select the button to the right of the "CO2 Conc (ppm):" text. The numerical keypad will appear allowing a new number to be entered.

4. Enter the CO_2 concentration of the reference gas. This value must match the certified CO_2 concentration of the reference source and be greater than or equal to the anticipated measurement range of the instrument. For example, if the anticipated measurement range of your samples will be 0 - 350 ppm, the instrument should be calibrated using reference gas with a CO_2 concentration between 350 – 400 ppm.

5. The EGM-5 will then perform a zero. At completion of successful zero, a similar message to the following will be displayed:

6. **Note, the displayed value may not be the value you entered in step 3 above.** When the Actual CO2 value has stabilized (i.e., not changing by more than 1 ppm after 30 seconds), press the Right arrow. To cancel without performing a Calibration, press Stop.

```
                Calibrate
        ---Wait for zero---
        Select OK button when
        actual value is steady.

        Set CO2 (ppm) =  600
        Actual CO2 (ppm) =  597

        Stop                    OK
```

Calibrate	
Set CO2	The CO_2 concentration value entered at the beginning of the Calibration Process.
Actual CO2	The current CO_2 reading.
Stop Button	Returns to the Calibration Menu with no changes.
OK Button	Calculates new Scale Factor and goes to next screen. Press to continue once the Actual CO2 value is stable (i.e., not changing by more than 1ppm after 30 seconds).

Note, the Actual value may not be the value you entered in step 4 above. When the Actual CO2 value has stabilized (i.e., not changing by more than 1 ppm after 30 seconds), press the OK button. To cancel without performing a Calibration, press Stop.

If the process is successful, the screen below will be displayed and the new calibration constant will be stored in non-volatile memory. If the process is unsuccessful, the message "Calibration: failed." will be displayed and no changes made.

```
            Calibration Results

        Calibration: succeeded.


        CO2 Scale Factor = 1.003
        Set CO2 (ppm) =  600
        Actual CO2 (ppm) =  601

        Back
```

The Back button returns the user back to the Main Menu.

O₂ Calibration

This function allows the user to recalibrate the internal O_2 sensor used with the EGM-5. Before calibrating, confirm that:

- The WMA-5 has been on for at least 30 minutes.
- The Gas Out port is unobstructed.

Calibrate

Enter value to begin.

O2 Conc (%):   `20.9`

Actual O2 (%) = 20.5
O2 Scale Factor = 1.059

`Stop`

Calibration	
O₂ Conc Button	O₂ concentration (%) of the calibration reference gas. Entering a value will begin the Calibration Process
Actual O₂	The current O₂ reading based on the Scale Factor
O₂ Scale Factor	The current Scale Factor being used
Stop Button	Returns to the Calibration Menu.

Connecting Calibration Gas to the EGM-5

During calibration, the signal from the O_2 sensor is referenced against a gas of known O_2 concentration.

For greater accuracy, reference gas mixtures should be accurate to at least +/- 1% and traceable to NIST standards.

Follow these instructions to calibrate the EGM-5 O2 sensor:

1. To avoid excess pressure in the sample cell and damage to the analyzer, you must place a T-fitting between the reference gas source and the **GAS IN** port on the EGM-5. One end of the T-fitting should be left open in order to relieve excess pressure, as follows:
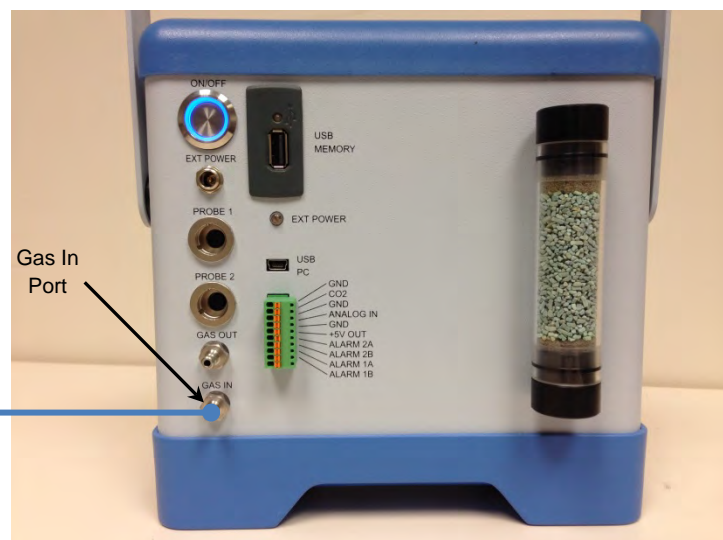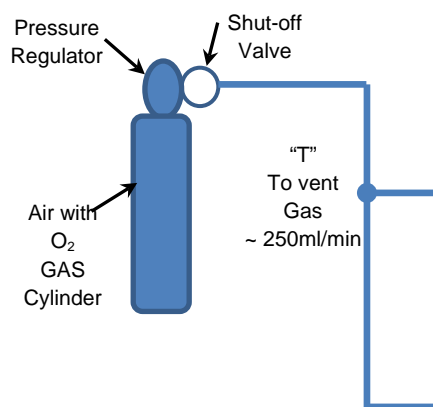
2. The pressure regulator on the reference source should be set to a very low pressure, such that the flow rate of excess gas from the open end of the T-fitting should be approximately 250 ml/min.

3. Select the button to the right of the "O2 Conc (ppm):" text. The numerical keypad will appear allowing a new number to be entered.

4. Enter the O_2 concentration of the reference gas. This value must match the certified O_2 concentration of the reference source and be greater than or equal to the anticipated measurement range of the instrument.

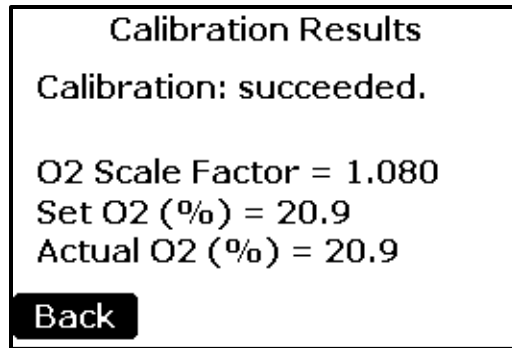5. The EGM-5 will then perform a zero. After completion of successful zero, a similar message to the following will be displayed.
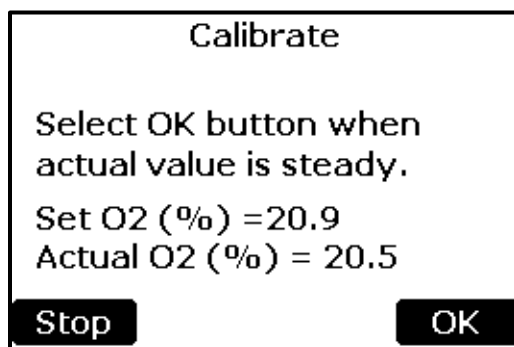
6. **Note, the Actual displayed value may not be the value you entered in step 3 above.** When the Actual O_2 value has stabilized (i.e., not changing by more than 0.1% after seconds), press the OK button. To cancel without performing a Calibration, press Stop.

Calibrate	
Set O₂	The O_2 concentration Value entered at the beginning of the Calibration Process.
Actual O₂	The current O_2 Reading
Stop Button	Returns to the Calibration Menu with no changes.
OK Button	Calculates new Scale Factor and goes to next screen. Select this button when the Actual O_2 value is steady (i.e., not changing by more than 0.1% after 30 seconds).

If the process is successful, the screen below will be displayed and the new calibration and linearization constants will be stored in non-volatile memory. If the process is unsuccessful, the message "Calibration: failed(xx)." will be displayed, where xx is the error code. See EGM-5 Command Set Table on page 96 for a description of calibration error codes.

```
   Calibration Results

 Calibration: succeeded.


 O2 Scale Factor = 1.080
 Set O2 (%) = 20.9
 Actual O2 (%) = 20.9

 Back
```

The Main button returns the user back to the Main Menu.

Touch Calibration

This function allows the user to calibrate the touch screen display. Follow the on-screen prompts to complete the process.

```
        Performing touch
        screen calibration.

        Touch screen to
          continue.
```
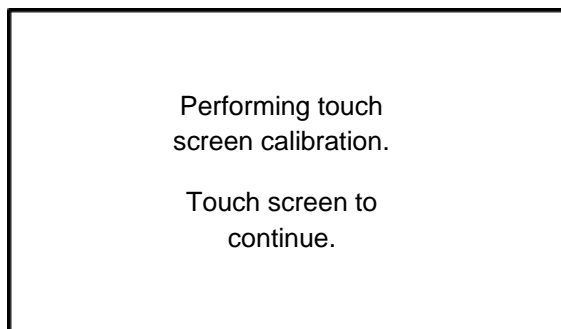
NOTE: This function can also be initiated by holding a finger on the screen while powering up the EGM-5. If your touch screen is not reacting to your touch:

1. Turn the instrument off.
2. Place your finger anywhere on the touch display and turn system power on and wait for the next screen to appear.
3. Proceed as directed with the touch screen calibration.

Diagnostics

This menu monitors and reports key system diagnostics associated with EGM-5 hardware. It is generally used for troubleshooting and diagnosing potential problems associated with the instrument.

```
      Diagnostics Menu
   ADC        Battery
   Zeros      Voltages
   Hours      Advanced

 Back
```
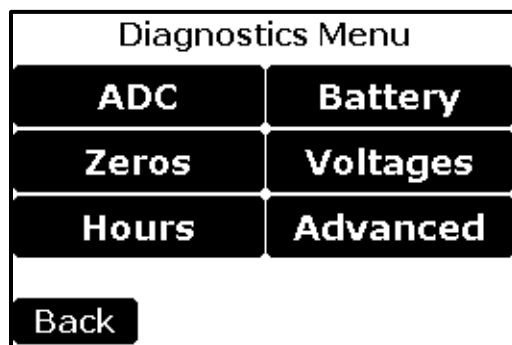
Diagnostics Menu	
ADC (analog digital converter)	Initiate zeros and view readings from the Analog to Digital (A/D) Converter, which are digital representations of CO_2 values.
Zeros	Displays the A/D counts for the last 7 zero operations.
Hours	Displays the amount of time (in hours) that the controller and IRGA have operated over their lifetime.
Battery	Displays the percentage of battery remaining, the voltage and current of the battery, and an estimate of time remaining before the battery is completely discharged.
Voltages	Displays the external voltage, the flow sensor voltage, the Aux (Analog Out) voltage and the O_2 sensor voltage.
Advanced	Displays more advanced diagnostics functions. These functions are password protected, and are for PP Systems use only.
Back	Returns to the Main Menu.

ADC (Analog Digital Converter) Diagnostics

This function allows the user to change/view the Diagnostic Mode, initiate a zero and view A/D count readings.

ADC Diagnostics	
CR	This is the reading from the 16 bit A/D converter for the CO_2 detector.
Diagnostics Mode (Measure)	Modify the Diagnostic Modes setting. The options are Measure or Zero. The text on the button indicates the current mode.
CZ	This is the A/D count reading from the last zero.
Start Zero	Initiates a zero.
Back	Returns to the Diagnostics Menu.

Diagnostic Mode

To change the Diagnostic Mode, select the button to the right of the CR reading. The Diagnostic Mode Setting screen will be displayed, with the current selection indicated.
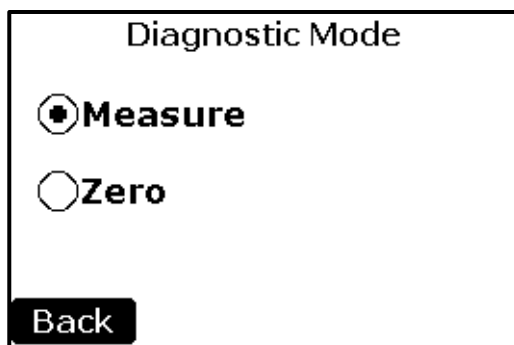
Press the desired Diagnostic Mode setting and then the Back button. The Diagnostics screen will return with the updated Diagnostics Mode value in the button text. In Zero mode, sample gas is continuously passed through the absorber column until the user returns to Measure Mode, or until the unit performs an Auto Zero.

Diagnostics Mode Setting	
Measure	Puts the EGM-5 into "Measure" mode. In Measure mode, the CR value should read approximately 35000-45000 for CO_2 concentrations around 400 ppm.
Zero	Puts the EGM-5 into "Zero" mode. In "Zero" mode, the A/D value for CR should read approximately 40000-50000 **if fresh soda lime is present in the absorber column**. The CR value in "Zero" mode should always be greater than the CR value in "Measure" mode.
Back	Returns to the Diagnostics display.
Status Box	Any information or error messages are displayed here.

Zeros Diagnostics

This screen displays the last 7 zero values.
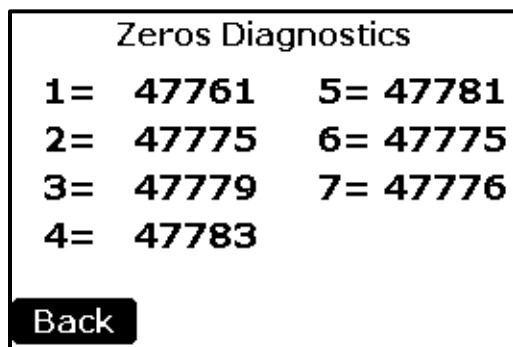
Zero Diagnostics	
1-7	The zero ADC value of the last seven zeros.
Back	Returns to the Diagnostics Menu.

Hours Diagnostics

This screen displays the amount of time (in hours) that the controller and IRGA have operated in the instrument's lifetime.

```
        Hours Diagnostics

Controller(hr) =    164.2

IRGA(hr) =          164.0

 Back
```

Hours Diagnostics	
Controller (hr)	Displays the total amount of time (in hours) that the controller has operated.
IRGA (hr)	Displays the total amount of time (in hours) that the IRGA has operated.
Back	Returns to the Diagnostics Menu.

Battery Diagnostics

This screen displays the percentage of battery remaining, the voltage and current of the battery, and the time remaining before the battery is completely discharged.

```
       Battery Diagnostics
     Charge (%) = 100%
     Voltage (V) = 8.330
     Current (A) = -0.364
    Time Left (M) =   1364

 Back
```

Battery Diagnostics	
Charge (%)	Displays the percentage of battery charge remaining.
Voltage (V)	Displays the battery voltage.
Current (A)	Displays the average battery current in Amps over the past 60 seconds. A negative value indicates discharge current and a positive value indicates the battery is being charged.
Time Left (M)	Displays the estimated remaining run time in minutes assuming the average current does not change. A value of 65535 is displayed during battery charging.
Back	Returns to the Diagnostics Menu.

Voltage Diagnostics

This screen displays the external voltage, the flow sensor voltage, the Aux voltage and the O_2 sensor voltage.

```
Voltage Diagnostics
   External (V) = 11.9081
   Flow Sen (V) =  1.7826
       Aux (V) =  0.0000
    O2 Sen (V) =  0.0000

 Back
```

Battery Diagnostics	
External (V)	Displays the applied voltage when power is supplied by the power adapter.
Flow Sen (V)	Displays the flow sensor voltage.
Aux (V)	Displays the Aux (Analog Out) voltage.
O2 Sen (V)	Displays the O_2 Sensor voltage.
Back	Returns to the Diagnostics Menu.

Advanced Diagnostics

This screen prompts the user to enter a password in order to view advanced diagnostics features. These functions are reserved for PP Systems service & troubleshooting use only.

```
Advanced Diagnostics



 Enter PIN          ****



 Back
```

Advanced Diagnostics	
****	Displays a number entry screen for the operator to enter their PIN.
Back	Returns to the Diagnostics Menu.

Information Menu
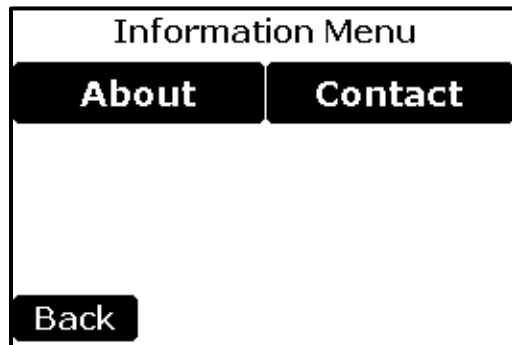
Information Menu	
About Button	Provides information about serial numbers and the firmware versions
Contact Button	Information to contact PP Systems
Back Button	Returns to the Main Menu.

About

This function allows the user to view hardware and software serial and version numbers.
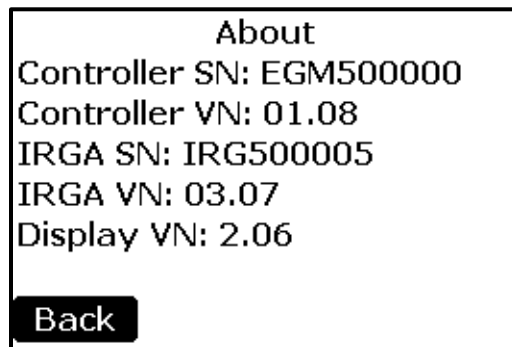
About	
Controller SN	Displays the Controller serial number. This is the also the instrument serial number.
Controller VN	Displays the Controller version number.
IRGA SN	Displays the IRGA serial number.
IRGA VN	Displays the IRGA version number.
Display VN	Displays the Display version number.
Back Button	Returns to the Settings 2 Menu.

Press "Back" to return to the Info Menu.

Contact

Contact	
Contact	Contact information for PP Systems.
Back Button	Returns to the Information Menu.

Data Storage

Data is stored directly to a USB Flash Drive for convenience. Generally speaking the data format will default to the proper M type format required for the specific sensor/chamber being used. All data is stored as a .txt file in standard ASCII format making it very easy to open and view in Excel. See the following sections for more information on data storage and measurement formats.

USB Flash Drive (Memory Stick)

The USB Type A port on the back panel is designed specifically for a USB flash drive (commonly referred to as a memory stick or thumb drive). Most memory sticks can be used and one is provided with the EGM-5. If you are using your own memory stick, ensure it is formatted as FAT32 with a 512-byte sector size for best performance.

Data recording begins when a flash drive is inserted into the USB port on the EGM-5 unless the Interval is set to 0 seconds under "Memory Measure Settings". Data recording ends when the flash drive is removed from the USB port. The data format depends on what has been defined for the Measure Memory Format in the Memory Measure Settings screen. The recording interval is defined in the Memory Measure Settings screen, under "Memory Measure Interval". For more information about data format and recording interval see Memory Measure Settings on page 48.

When the memory stick is inserted for the first time, a directory named "EGM5" is created. A filename is created within the directory using the following format:

YYMMDDWI.txt

Where:
- YY is the last 2 digits of the calendar year.
- MM is the 2 digit month.
- DD is the 2 digit day.
- W is the EGM ID (0-9).
- I is the increment of the file if there is more than one file created in a day.

Each time the memory stick is removed and then reinserted, or when the instrument is power cycled, a new file is created and the increment 'I' is increased. Any files in this directory with extensions other than .txt do not contain valid data and may be deleted or ignored.

Even if the Measure Interval is set to 0, Zero Operations and Process data are still sent to the USB, even though CO_2 measurement data is not.

Refer to Error Messages on page 117 for disk errors.

Data Storage/Measure Format Settings Table

This table describes the different data storage information and measurement formats available in the EGM-5.

General M Format		
Mtype	1-6	M
Date	dd/mm/yy	Header
Time	hh:mm:ss (24hr)	
Plot No.	0-999	
Rec No.	1-9999	
CO$_2$ Ref	CO_2 reading in parts per million (ppm = μmol mol^{-1})	Measured Data
AP	Atmospheric pressure in millibars (mb)	
Flow	Sample flow (cc/min)	
H$_2$0 Ref	H_2O reading in millibars (mb) (**if optional H$_2$O sensor is installed**).	
RHT	Temperature of RH sensor (˚C) (**if optional H$_2$O sensor is installed**).	
O$_2$ Ref	O_2 percentage (**if optional O$_2$ sensor is installed**).	
Error Code		
Aux (Analog Out) Voltage	Volts	Probe Data
PAR	PAR: μmol m^{-2} s^{-1}	
Temperature Soil	˚C	
Temperature Air	˚C	
RH	Relative Humidity (%)	
Parameter 1		Process Data
Parameter 2		
Parameter 3		
Parameter 4		
Parameter 5		

Process Data Fields

The process data fields are based on the measurement mode used with the EGM-5. The 5 different modes available are:

1. Measure mode
2. SRC or Custom mode
3. CPY Mode
4. Injection mode
5. Static mode

Process Data Format (measure mode)			
Parameter 1	Probe Type	0-19	Process Data
Parameter 2	Battery %	Battery charge (0-100%)	
Parameter 3	Zero %	Absorber capacity (0-100%)	
Parameter 4	Bat Volts	Battery voltage (volts)	
Parameter 5	Bat Time	Battery time remaining (minutes)	

Process Data Format (SRC, CUSTOM mode)			
Parameter 1	Process	20, 60	Process Data
Parameter 2	DC	Change in CO_2 concentration (ppm)	
Parameter 3	DT	Process runtime (seconds)	
Parameter 4	SRL Rate	(Assimilation): grams (CO_2) m^2 Hour^{-1}	
Parameter 5	SRQ Rate	(Assimilation): grams (CO_2) m^2 Hour^{-1}	

Process Data Format (CPY mode)			
Parameter 1	Process	50	Process Data
Parameter 2	DC	Change in CO_2 concentration (inverted) (ppm)	
Parameter 3	DT	Process runtime (seconds)	
Parameter 4	SRL Rate	(Respiration): µmol m^2 s^{-1}	
Parameter 5	SRQ Rate	(Respiration): µmol m^2 s^{-1}	

Process Data Format (Injection mode)			
Parameter 1	Process	30,31	Process Data
Parameter 2	C_F	Correction Factor (0.5 – 2.0)	
Parameter 3	Volume	Syringe sample volume (cc)	
Parameter 4	Base	CO_2 Baseline (ppm)	
Parameter 5	CO₂ int	CO_2 Integration value (ppm)	

Process Data Format (Static mode)			
Parameter 1	Process	40	Process Data
Parameter 2	n/a	0	
Parameter 3	DT	Process runtime in seconds	
Parameter 4	CO₂	CO_2 reading (ppm)	
Parameter 5	n/a	0	

Measure Format Settings Table

This table describes the 6 different Measure Formats for data output. Note: A CRC, or Cyclic Redundancy Check, may be appended to measurement data to ensure its integrity. In the examples below, the CRC parameter is turned off and there are no CRCs concatenated to the end of a message. <CR> represents a carriage return (ASCII 13).

Measure Format Setting	
Setting	**Description**
M1	M1 is Header and Measured data only. The parameters are comma delimited. There are 12 fields. An example is: M1, 03/06/15, 09:32:15, 1, 0003, 1094, 1004.2, 327, 0.0, 00.0, 20.41, 00<CR> The format is as follows: • M1: Specifies the data format. • Date: dd/mm/yy • Time: hh:mm:ss • Plot No: 0-999 • Record No: 1-65535 • CO_2 (ppm): CO_2 reading in parts per million (ppm = µmol mol^{-1}) • Air Pressure (mb): Atmospheric pressure • Flow Rate (cc/min): Rate of flow. • H_2O (mb): H_2O reading • H_2O Sensor Temperature (°C): Temperature of the gas sample. • O_2(%): O_2 reading • System Error: Displays error code message. (See Error Messages table)
M2	M2 is Measured data only. The parameters are comma delimited. There are 8 fields. An example is: M2, 1094, 1004.2, 327, 0.0, 00.0, 20.41, 00<CR> The format is as follows: • M2: Specifies the data format. • CO_2 (ppm): CO_2 reading in parts per million (ppm = µmol mol^{-1}) • Air Pressure (mb): Atmospheric pressure • Flow Rate (cc/min): Rate of flow. • H_2O (mb): H_2O reading • H_2O Sensor Temperature (°C): Temperature of the gas sample. • O_2(%): O_2 reading • System Error: Displays error code message. (See Error Messages table)
M3	M3 is Header, Measured data, and Probe data only. The parameters are comma delimited. There are 17 fields. An example is: M3, 03/06/15, 09:32:15, 1, 0003, 1094, 1004.2, 327, 0.0, 00.0, 20.41, 00, 0.000, 825, 23.4, 25.7, 12<CR>

	The format is as follows: • M3: Specifies the data format. • Date: dd/mm/yy • Time: hh:mm:ss • Plot No: 0-999 • Record No: 1-65535 • CO_2 (ppm): CO_2 reading in parts per million (ppm = μmol mol^{-1}) • Air Pressure (mb): Atmospheric pressure • Flow Rate (cc/min): Rate of flow. • H_2O (mb): H_2O reading • H_2O Sensor Temperature (°C): Temperature of the gas sample. • O_2(%): O_2 reading • System Error: Displays error code message. (See Error Messages table) • Aux Voltage (volts): Analog Output Voltage. • PAR: (ppm = μmol m^2 s^{-1}) • Tsoil: Temperature (°C) • Tair: Temperature (°C) • RH: Percent Humidity
M4	M4 is Measured data and Probe data only. The parameters are comma delimited. There are 13 fields. An example is: M4, 1094, 1004.2, 327, 0.0, 00.0, 20.41, 00, 0.000, 825, 23.4, 25.7, 12<CR> The format is as follows: • M4: Specifies the data format. • CO_2 (ppm): CO_2 reading in parts per million (ppm = μmol mol^{-1}) • Air Pressure (mb): Atmospheric pressure • Flow Rate (cc/min): Rate of flow. • H_2O (mb): H_2O reading • H_2O Sensor Temperature (°C): Temperature of the gas sample. • O_2(%): O_2 reading • System Error: Displays error code message. (See Error Messages table) • Aux Voltage (volts): Analog Output Voltage. • PAR: (ppm = μmol m^2 s^{-1}) • Tsoil: Temperature (°C) • Tair: Temperature (°C) • RH: Percent Humidity
M5	M5 is Header, Measured data, Probe data, and Process data. The parameters are comma delimited. There are 22 fields. An example is: M5, 03/06/15, 09:32:15, 1, 0003, 1094, 1004.2, 327, 0.0, 00.0, 20.41, 00, 0.000, 0, 23.4, 0, 0, 1 ,76 ,89.56, 7.231, 480<CR> The format is as follows: • M5: Specifies the data format. • Date: dd/mm/yy • Time: hh:mm:ss • Plot No: 0-999

	- Record No: 1-65535 - CO_2 (ppm): CO_2 reading in parts per million (ppm = μmol mol^{-1}) - Air Pressure (mb): Atmospheric pressure - Flow Rate (cc/min): Rate of flow. - H_2O (mb): H_2O reading - H_2O Sensor Temperature (°C): Temperature of the gas sample. - O_2(%): O_2 reading - System Error: Displays error code message. (See Error Messages table) - Aux Voltage (volts): Analog Output Voltage. - PAR: (ppm = μmol m^2 s^{-1}) - Tsoil: Temperature (°C) - Tair: Temperature (°C) - RH: Percent Humidity - Parameter 1 (See Process Data Fields on page 91) - Parameter 2 (See Process Data Fields on page 91) - Parameter 3 (See Process Data Fields on page 91) - Parameter 4 (See Process Data Fields on page 91) - Parameter 5 (See Process Data Fields on page 91)
M6	M6 is the raw format containing raw data (A/D values) from the IRGA. It is comma delimited. An example is: M6, 44572, 50675, 17603, 17600, 37340, 50292,0x0040<CR> The format is as follows: - M6: Specifies the data format. - CO_2 A/D Counts: Proportional to the CO_2 reading. - Air Pressure A/D Counts: Proportional to the atmospheric pressure reading. - Temperature Probe1 A/D Counts: Proportional to the temperature of probe 1. - Temperature Probe2 A/D Counts: Proportional to the temperature of probe 2. - Lamp A/D Counts: Proportional to lamp current. - Last Zero CO_2: Reports A/D counts of the last zero value. - System Error: Displays error code message. (See Error Messages table)

Digital Connection Methods

There are two methods of connecting to the EGM-5 to view digital data:
1. PC USB port
2. Wireless (if WiFi Option is installed).

USB

A USB cable (Mini-B to Type A) can be used to connect the EGM-5 to a host device such as a PC, laptop or tablet. This cable is supplied by PP Systems with every EGM-5. When using a terminal emulator, the COM port settings to communicate with the EGM-5 are: 19200 baud, 8 bit, 1 stop, no parity, no flow control.

Wireless

If WiFi option is installed, there are two additional connection methods available: First, a direct wireless connection (up to 15m) between any wireless device (e.g., phone, tablet, or laptop) and the EGM-5 can be made without any additional hardware or routers. Second, the EGM-5 can be connected to the customer's wireless router, which makes it accessible via the customer's Local Area Network (LAN). The customer's network may also be configured to allow remote connections to the EGM-5 over the Internet if firewall settings and security protocols are properly configured (see your Network Administrator). PP Systems is not responsible for any security risks associated with modifying network or firewall settings.

Digital Communication Protocols and Software

Once a connection is made to the EGM-5 as described in the previous section, communication software is needed to read, display, and record data. This section describes three methods for reading EGM-5 data and changing settings: the EGM-5 Command Set, for direct communication using EGM-5 ASCII character strings; GAS Software, for a Windows based graphical user interface with graphing and logging; and Web Pages, which are available only with the WiFi Option.

EGM-5 Command Set

When a computer is connected to the EGM-5 using a USB cable, a communication protocol and command set comprised of ASCII characters and strings allows receipt of EGM-5 data and setting of EGM-5 parameters. A terminal emulation program (e.g., HyperTerminal or PuTTY) is generally used for this, but other custom software may also be used to observe and interact with the EGM-5 using these commands.

Measured data is continuously output by the EGM-5. The time interval can be modified using the Host Measure Interval setting (default is every 1 second). The data format is dependent on the Host Measure Format setting. Refer to Host Measure Settings on page 46 for more information.

Sending a command

To initiate a command, the Host (e.g., a PC running HyperTerminal) sends an ASCII string in comma-delimited format to the EGM-5. The command can be sent with or without a CRC-8 (9-bit Cyclic Redundancy Check). If a CRC-8 is sent, a 'C' follows the CRC-8 value.

For example,
Host sends command without CRC-8: S,1,25<CR>
Host sends command with CRC-8: S,1,25,080C<CR>

The CRC calculation includes everything but the CRC itself and the 'C' character. In the example above, the CRC was calculated from the string "S,1,25,".

The command is processed by the EGM-5 after the command string terminator <CR> is received.

Only commands that are less than 90 characters in length will be successful. If a CRC-8 is present, the CRC-8 also needs to be correct in order for the command to be successful.

On successfully receiving the command string, EGM-5 sends an acknowledgement by sending to the Host a '+' followed by a <CR>.

On a failure, a '–' is sent back to the Host with a <CR>.

A failure can be caused by a string longer than 90 characters or an incorrect CRC.

Receiving a response

Depending on the value of the CRC parameter, a CRC will/will not be appended to the command received from the EGM-5. If the CRC parameter value is '0' (CRC Off), no CRCs will be appended to any of the commands received from the EGM-5. If the CRC parameter value is '1' (CRC On), CRCs will be appended (including the 'C') to all commands received from the EGM-5. See Get/Set Parameter Values Table on page 106 for more details on turning off/on the CRC.

For example,
With CRC=0 (CRC Off):
Received from EGM-5:   G,1,25<CR>

With CRC=1 (CRC On):
Received from EGM-5:   G,1,25,043C<CR>

The following table describes the EGM-5 Command Set that can be used by the Host to communicate with the EGM-5. Note, the examples shown below have CRC disabled (CRC=0). There are two types of commands; Auto and Standard. Auto commands are commands that the EGM-5 will send without being prompted by the user. For example, the 'W' (Warm Up) command is automatically sent by the EGM-5 when it is warming up. Standard commands are commands that are sent by the user. Standard commands can be only a single character, or a single character followed by one or more parameters. All commands are terminated with <CR> which represents a carriage return (ASCII 13).

EGM-5 Auto Strings

Auto Strings are text strings that are sent by the EGM-5 automatically under certain states and conditions

EGM-5 Auto Command Set		
String	Type	Description
*	Auto	## "*" String (Power Reset) Sent immediately after the EGM-5 is turned on or reset. Example: *\<CR>
E	Auto	## "E" String (Error Status) Transmitted whenever an error is detected. The E string contains an Error Code that indicates the problem. See Error Messages on page 117 for more details. Example: E,11\<CR> In this example, 11 is the code for the Low CO_2 Alarm.
M	Auto	## "M" String (Measurements) The M string is sent on a fixed interval. The interval and the string format may be modified. When the interval is set to 0 the M string stops sending automatically, but can be manually polled by sending the "M" command. Example: M3, 03/06/15, 09:32:15, 1, 0003, 1094, 1004.2, 327, 0.0, 00.0, 20.41, 00\<CR> In this example, the Measure Format setting had been set to 3. See Measure Format Settings Table on page 93 for more details.

V	Auto	## "V" String (Versions)
		
		This is sent once right after the EGM-5 is powered on, or if the system is reset. The V string contains the serial numbers and software versions of the EGM-5 controller, the IRGA and the Display.
		
		Example:
		V,EGM500007,01.02,IRGA00001,01.01\<CR>
		
		In this example,
		    EGM500007 is the EGM-5 serial number
		    01.02 is the EGM-5 firmware version number
		    IRGA00001 is the IRGA serial number
		    01.01 is the IRGA firmware version number

W	Auto	## "W" String (Warm up)
		
		The W string is transmitted every second during initial warmup, until the operating temperature is reached. No "M" strings are sent during this time. The W string contains the IRGA temperature, Battery Percent, and the Zero Column Percent.
		
		Example:
		W,55.0, 80, 59.47<CR>
		
		In this example,
		      55.0 is the IRGA temperature (°C).
		      80 is the Battery % of Charge
		      59.47 is the Remaining Zero Column Capacity

Z	Auto	## "Z" String (Zeroing)
		
		The Z string indicates a zero in progress. During a zero operation, the EGM-5 transmits the Z string every 1 second, until the end of the zero operation. No "M" strings are sent during this time. This command can be initiated by the user or by the EGM-5 itself.
		
		Example:
		      Z, 025<CR>
		      Z, 024<CR>
		      …
		
		In this example, 025 and 024 represent the number of seconds remaining in the zero operation.

EGM-5 Command Set Table

Command	Type	Description
'	Character	**" ' " Command (Comment)** This command ignores any characters between the quote and <CR>. This is useful for documentation; for example, it allows comments in a configuration file to be ignored when the file is uploaded. Example: Sent from Host: ' This file sets all the default values<CR> Received from EGM-5: +<CR>
A,x,y	Character with Parameters	**"A" Command (Relays on/off)** This command is the diagnostic toggle for the alarm relay. x='1' for ALARM1 Relay x='2' for ALARM2 Relay y='0' for Relay Off y='1' for Relay On Example: Sent from Host: A,1,1<CR> Received from EGM-5: +<CR> A,1,1 In this example, ALARM1 relay would be set to on.
B	Character	**"B" Command (Status info)** This command returns 5 Parameters: Battery Capacity (%), Battery Voltage (Volts), Battery Current (Amps), Battery time remaining (minutes), and Absorber remaining (%). Example: Sent from Host: B<CR> Received from EGM-5: +<CR> B,100, 7.2, 0.546, 752, 99.1<CR> In this example, Battery Capacity (%) = 100% Battery Voltage (Volts) = 7.2 Volts Battery Current (Amps) = 0.546 Amps Battery time remaining = 752 minutes Absorber remaining (%) = 99.1%
C,d,a,c	Character with Parameters	**"C" Command (Calibration)** d = device

		$1 = CO_2$ IRGA
		$2 = O_2$ sensor
		
		a = Action
		    0 = Calibrate
		    1 = Reset Calibration Factor to 1.0
		    2 = read Current Factor
		
		c = Calibration Value
		
		RETURNED STRING:
		
		C,d,a,c,f,e<CR>
		
		f = New Calibration Factor
		
		e = Status Code / Error Code
		    SUCCESS = 0
		    NO_FORMAT = 10
		    NO_DEVICE = 11
		    NO_ACTION = 12
		    CAL_VALUE_OOR_CO2 = 13
		    CAL_FACTOR_OOR_CO2 = 14
		    CALIBRATION_FAILED = 15
		    CAL_VALUE_OOR_O2 = 16
		    CAL_FACTOR_OOR_O2 = 17
		
		EXAMPLE:
		
		1. Calibrate to a 2000ppm CO_2 reference gas
		
		    Example:
		    Sent from Host: C,1,0,2000<CR>
		    Received from EGM-5:
		    +<CR>
		    C,1,0,2000,1.091,0
		
		    In the example, the CO_2 reading is 2000 and the calibration factor is 1.091.

F,x	Character with Parameters	**"F" Command (Zero Valve on/off)** This command sets the Zero Valve. x='0' Off x='1' On Example: Sent from Host: F,1<CR> Received from EGM-5: +<CR> F,1 In this example, Zero Valve would be set to on.
G,x	Character with Parameters	**"G" Command (Get Setting)** This command gets a parameter stored in EEPROM (non-volatile memory). x

		corresponds to a parameter value (See Get on page 106). When G,x is sent from the Host, the value associated with that particular parameter is returned. Example: Sent from Host: G,1<CR> (Get Zero Type) Received from EGM-5: +<CR> G,1,1.000<CR> In this example the value of Zero Type is 1 (Automatic).

H,x	Character with Parameters	**"H" Command (Get Run Hours)**
		
		This command gets the total hours of unit operation. The x parameter is the number that determines the module the hours is retrieved from.
		
		Module number:
		      1 = Main Controller
		      4 = IRGA Module
		Example:
		Sent from Host: H,1<CR>
		Received from EGM-5:
		+<CR>
		H,1, 463.1
		
		In this example, the main controller has reported 463.1 hours of operation.

Mx	Character with Parameters	**"M" Command (Measure String)** This command performs a "one shot" measurement output. Each time 'Mx' is sent to the instrument, one set of data is displayed in the currently specified format (i.e., M1, M2, etc.). The value of x determines where the data will be sent: H=Host M=Memory Stick W=Wireless A=All three Example: Sent from Host: MH<CR> Received from EGM-5: +<CR> M3, 03/06/15, 09:32:15, 1, 0003, 1094, 1004.2, 327, 0.0, 00.0, 20.41, 00<CR> In this example, the data is sent to the Host only. The Host Measure Format setting had been set to 3. See Get/Set Parameter Values Table on page 106 for more details.
N	Character	**"N" Command (Read Voltages)** This command returns five system voltage measurements in volts. External Voltage, System Voltage, Flow Sensor Voltage, AUX1 (Analog Output) Voltage and O_2 Sensor Voltage are sent in order in comma-delimited format. Example: Sent from Host: N<CR> Received from EGM-5:

		+<CR> N,12.1324, 6.6143, 0.4765, 0.0000, 0.0000<CR> In this example, External Voltage=12.1324, System Voltage=6.6143, Flow Sensor Voltage=0.4765, AUX1 Voltage=0.0000 and O_2 Sensor Voltage=0.0000.
P,x	Character with Parameters	**"P" Command (Process Modes)** This command is used to Select and Control a process. The x parameter determines which Process action will be performed. **Description of x:** 1 = Stop process (returns to standard Measure mode) 2 = Stop process and Save Last Measurement 3 = Save Last Measurement 4 = Fan on High Speed 5 = Fan on High Speed and stop Zeros 6 = Fan on low speed 7 = Fan on low speed and start Zeros 20 = Start the SRC process or Restart if already running 30 = Start the Injection process or Restart if already running 40 = Start the Static process or Restart if already running 50 = Start the CPY process or Restart if already running 60 = Start the Custom process or Restart if already running Example: Sent from Host: P,20<CR> (Start SRC process) Received from EGM-5: +<CR> In this example the SRC process is started.
S,x,v	Character with Parameters	**"S" Command (Save Setting)** This command sets a parameter in EEPROM (non-volatile memory). The x parameter specifies a particular setting, and the v parameter is the desired value of the particular setting, which will be saved in the EEPROM. A 'G' command is returned to confirm that the request was accepted. See Get/Set Parameter Values Table on page 106. Example:

		Sent from Host: S,1,1<CR> Received from EGM-5: +<CR> G,1,1.00<CR> In this example, Zero Type is set to 1 (Automatic).

T	Character
	&
	Character
	with
	Parameters
		"T" Command (Time)
		
		This command gets and sets the time in 24-hour format. The command can be implemented in three different ways:
		
		1. Get values: The 'T' command is used to get the complete set of day/time values.
		
		   Example:
		   Sent from Host: T<CR>
		   Received from EGM-5:
		   +<CR>
		   T,04,42,15,05,01,15<CR>
		
		   In this example, seconds=04, minutes=42, hour=15, day=05, month=01 and year=(20)15.
		
		2. Set All Parameters: The 'T' command can be used to set all of the day/time values at once.
		
		   Example:
		   Current time: 05/01/2015 15:42:04
		   Sent from Host: T,04,42,10,05,02,15<CR>
		   Received from EGM-5:
		   +<CR>
		   T,04,42,10,05,02,15<CR>
		
		   In this example, hour is changed from 15 to 10 and month is changed from 1 to 2. If any one of the attributes is different from the current the value, it will be updated.
		
		3. Partial Parameter Set: The 'T' command can be used to set particular attributes of the day/time values using 1-6, where 1=seconds, 2=minutes, 3=hour, 4=day, 5=month and 6=last 2 digits of year.
		
		   Example:
		   Sent from Host: T<CR> (Get current time)
		   Received from EGM-5:
		   +<CR>
		   T,04,42,15,05,01,15<CR>
		   Sent from Host: T,3,11<CR>
		   Received from EGM-5:
		   +<CR>
		   T,4,42,11,05,02,15<CR>
		
		   In this example, the hour was changed from 10 to 11. All other values stayed the same.

V	Character	**"V" Command (Get Versions)**

		This command returns the serial numbers and software versions of the EGM-5 controller, the IRGA and the Display. Example: Sent from Host: V<CR> Received from EGM-5: +<CR> V,EGM500007,01.02,IRGA00001,01.02<CR> Where, in this example, EGM-5 serial number= EGM500007 EGM-5 firmware version number=01.02 IRGA serial number=IRGA00001 IRGA firmware version number=01.02
X	Character	**"X" Command (Get Zeros)** This command retrieves the A/D counts for the last seven zeros performed Example: Sent from Host: X<CR> Received from EGM-5: +<CR> X, 44200, 44223, 49971, 49972, 49976, 49981, 49973<CR>
Z	Character	**"Z" Command (Do a Zero)** This command initiates a zero. During a zero operation, the EGM-5 transmits a Z string every second until the end of the zero operation. No "M" strings are sent during this time. This command can be initiated by the user or by the EGM-5 itself. Example: Sent from Host: Z<CR> Received from EGM-5: +<CR> Z, 025<CR> Z, 024<CR> … A zero has been initiated by the user. In this example, 025 and 024 indicate the number of seconds remaining in the zero operation.

Get/Set Parameter Values Table

Get/Set Parameter Values				
Number (X)	Parameter Name	Description	Valid Values	Default Value
1	Zero Type	See Zero Settings on page 34. The values are: 1=Automatic, 2=User Set, 3=Manual	1-3	1
2	Zero Time (min)	See Zero Settings on page 34.	1-40	20
3	Average Limit (ppm)	See Averaging Settings on page 43.	0-100	30
4	Alarm Low (ppm)	See Alarms Settings on page 37.	0-100000	250
5	Alarm High (ppm)	See Alarms Settings on page 37	0-100000	2000
6	Alarm Sound	See Alarm Sound on page 39.	0=Off; 1=On	1
7	CO_2 Concentration (ppm)	See Analog Voltage Output on page 22.	100-100000	2500
8	EGM ID	See EGM ID on page 44.	0-9	1
9	Pump Power (%)	Percentage of the pump power (i.e., air flow).	0-100	60
10	Host Measure Format	See Host Measure Settings on page 46 for more information.	1-6	3
11	Host Measure Interval (seconds)	See Host Measure Settings on page 46 for more information. Use '0' for manual mode to stop broadcast.	0-3600	1
12	Memory Measure Format	See Memory Measure Settings on page 48.	1-6	3
13	Memory Measure Interval (seconds)	See Memory Measure Settings on page 48.	0-3600	1
14	WIFI Measure Format	See WiFi Measure Settings on page 48.	1-8	8
15	WIFI Measure Interval (seconds)	See WiFi Measure Settings on page 48.	0-3600	0
16	Display Measure Format	See Memory Measure Settings on page 48. Note: Interval is always 1 second.	5,6	5
17	CRC	Determines whether a CRC-8 will be appended to each command sent from the EGM-5.	0=Off; 1=On	0
18	Web Monitor	Adds terminator to strings sent to the WiFi Port to use for web pages	0=Off; 1=On	1
19*	Host Serial	Selects which Serial Host input to use: USB or WiFi	0=USB 1= WiFi	0

20	Chamber Volume (cc)	The volume of the measuring chamber (cc)	10-100000	1171
21	Chamber Area (cm^2)	The surface area of the chamber	1- 10000	78
22	CO_2 limit (ppm)	The CO_2 sampling limit	1-1000	50
23	Time Limit (Sec)	The sampling time limit	10-300	60
24*	Plot Number	Plot number (not saved in EEPROM) Defaults to 1 on power up	0-999	1
25*	Used Absorber (mm^3)	The volume of absorber material consumed by each zero operation (mm^3)	0-100000	Resets to zero when absorber is refreshed
26	Absorber Volume (mm^3)	Zero column volume (mm^3)	100-100000	20000
27	Syringe Volume	Gas sample volume (cc)	1 - 1000	10
28	Correction Factor	Correction factor for injection mode	0.5 – 2.0	1
29	SRC Volume (cc)	SRC chamber volume (cc)	1000 - 2000	1171
30	SRC Area (cm^2)	SRC Chamber surface area	50 - 100	78
31	CPY Volume (cc)	CPY Chamber volume (cc)	1000 - 5000	2427
32	CPY Area (cm^2)	CPY surface area	150 - 200	167
33	Chamber Air Temperature	Chamber Air Temperature in degrees C	0 - 50	20
34	Ship Mode	Used to prevent power turning on, Must have external power to exit mode	0 = Normal 1 = Ship Mode	0
35	Probe 1 Function	Select the functionality of probe 1 port.	0 = I2C 1 = PAR2 2 = SoilTemp 3 = SoilMoist 4 = NewProbe	0
36	Wi-Fi Power	Turns the Wi-Fi Power on / off	0 = OFF 1 = ON	0
37	Probe 2 Function	Select the functionality of probe 2 port.	0 = I2C 1 = PAR2 2 = SoilTemp 3 = SoilMoist 4 = NewProbe	0
38*	Flow Rate	Presently ignores setting value But sends back actual flow rate	0 - 600	300

*These parameters' values will not be affected by restoring to defaults (Main > Settings > Settings 4 > Defaults).

GAS (Gas Analysis Software)

PP Systems Windows® based GAS (Gas Analysis Software) software is available for displaying and logging CO_2 data from the EGM-5, and any additional environmental probes connected to it. No programming or command-line knowledge is required to utilize the GAS software. Connection between the EGM-5 and computer is via the USB interface. GAS will run on Windows XP and above.

The GAS software is included on the flash drive that comes with each new instrument (Part No. 10182-1), under the "PC Utilities\GAS_v[x]" directory, where [x] is the version number. GAS is also available for download directly from our website (for registered users only). To install GAS, double click on "setup.exe". A number of standard installation windows will be shown to guide you through the installation process. Once GAS is installed, the following icon will appear on the desktop:

GAS

Double click this icon to start GAS. Click Choose Device and choose EGM-5.
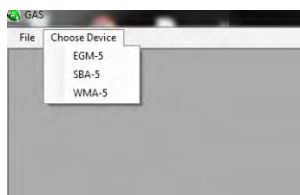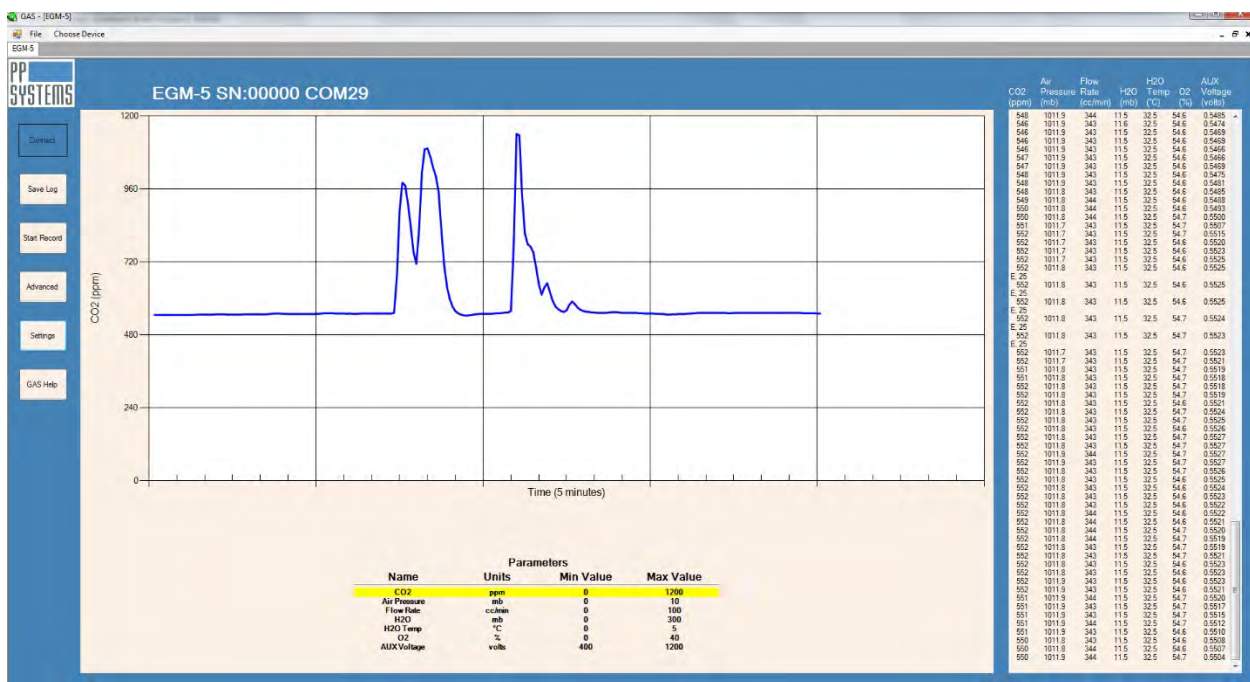

A new EGM-5 tab window will appear. Next, click the Connect button.
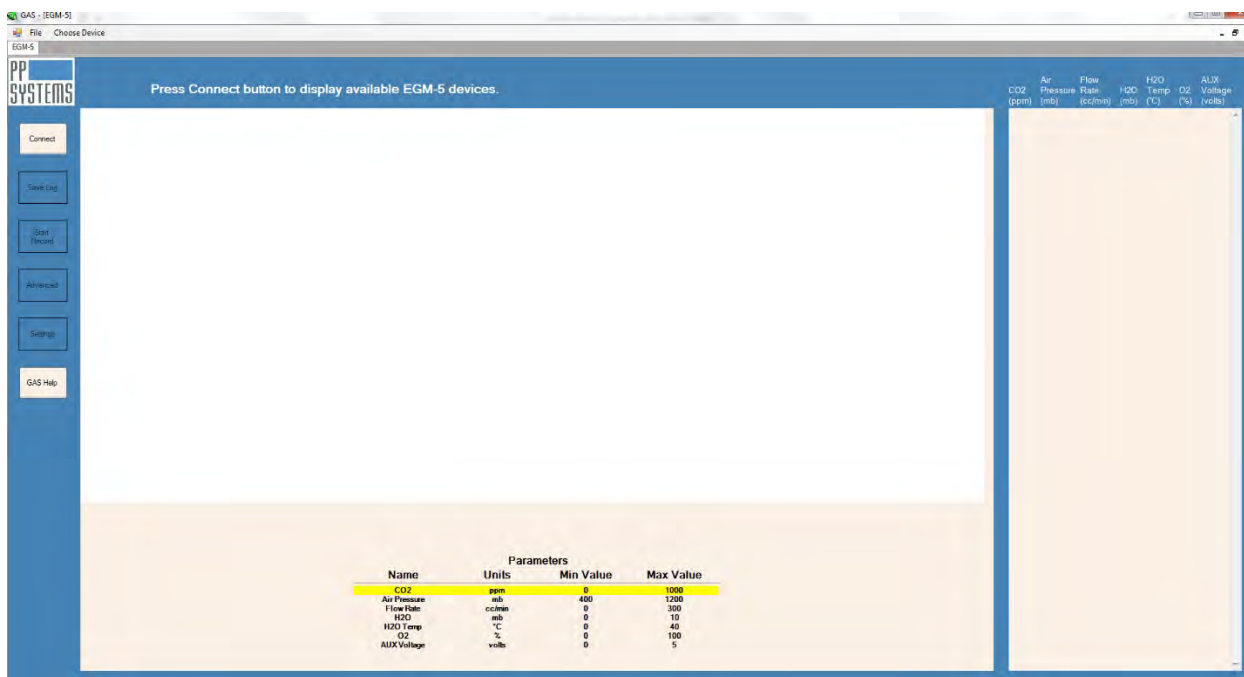
In the top left corner, a box will appear listing all available EGM-5 devices. Select one and click OK.
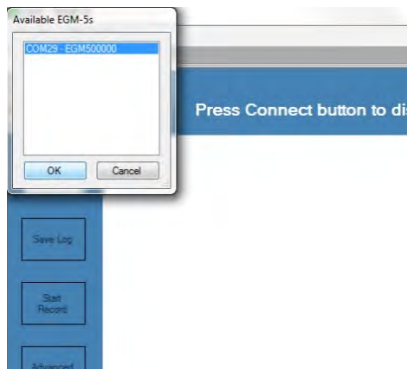
After clicking OK, the main measurement screen will be displayed.

Note: In the top left area, the device name (e.g., EGM-5, SBA-5 or WMA-5), serial number, and COM port are all displayed. Data is displayed both graphically and numerically. GAS gives the ability to log past data activity in a current session (Save Log) or record data (Start Record) for a time segment. Clicking the Advanced button will show a command-line window for sending commands directly to and from the EGM-5. The Settings button allows the user to modify the parameters' minimum and maximum values. Data is saved in comma-delimited .txt files. A graphical representation of each parameter can be seen by clicking the parameter name in the table below the graph. The highlighted parameter will be displayed on the graph.

For more detailed information on the functionality of GAS, refer to "Gas Help" under the Help menu in the software.

Web Pages

The WiFi option adds the ability for the EGM-5 to 'serve' web pages to most browsers. The simple browser-based interface is similar to the EGM-5's display. An overview of web pages is shown below.
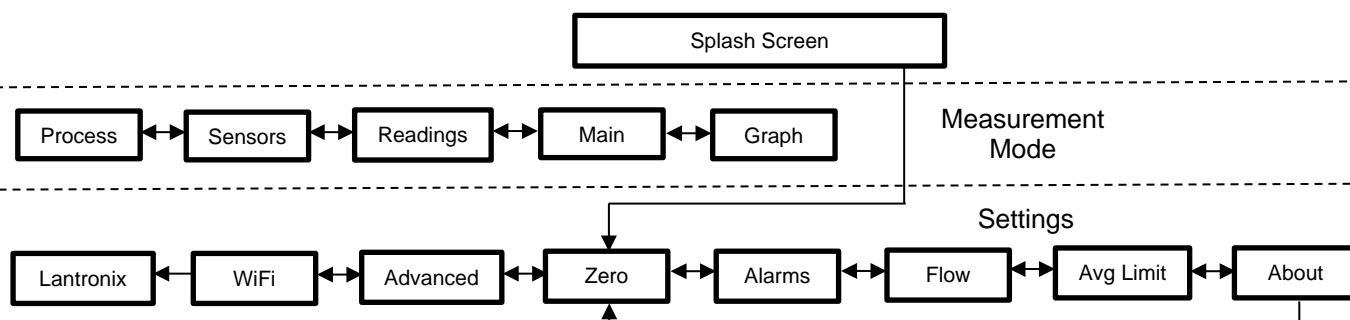
This capability allows users to continuously monitor CO_2 readings and set certain values from any device with a browser (such as iPhones, Android phones, tablets, laptops, and PCs), potentially anywhere in the world.

Splash Screen

The Splash Screen is the first screen displayed. There are two buttons the user can choose from: Main and Settings. To return to the Splash screen while in any other screen, click the PP Systems logo in the top left corner of the screen.
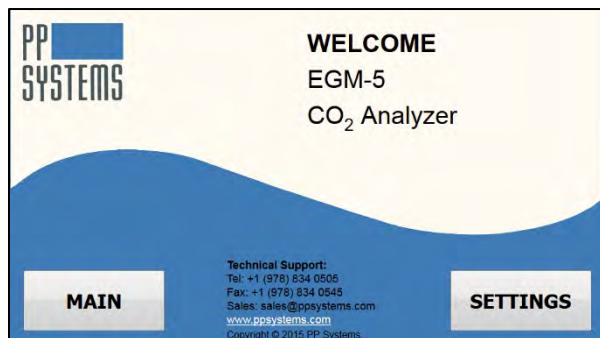
Splash Screen	
Main	Displays the Measurement Mode screens. These screens include Main (Measure), Graph, Readings, Sensors and Process.
Settings	Displays the Settings screen, which offers a subset of the Settings available on the instrument. These screens include Zero, Alarms, Flow, Avg Limit, About, Advanced and Lantronix

Measurement Mode Screens

The Measurement Mode screens are purely informational screens that allow the user to monitor data in a number of different ways. Below is the Main display, similar to the Measure screen on the instrument display. Refer to the Measurement Mode Screens table below for other screen descriptions.
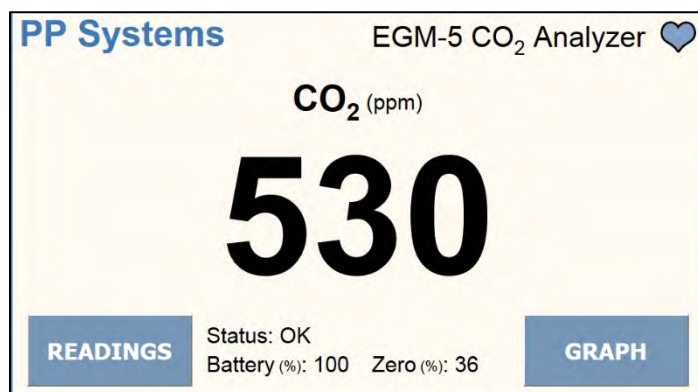
Measurement Mode Screens	
Main Screen	Displays the CO_2 concentration.
Graph Screen	Displays CO_2 concentration graphically over time.
Readings Screen	Displays the values of six parameters in real time; CO_2, H_2O, O_2, H_2O Temperature, Flow Rate and Air Pressure.
Sensors Screen	Displays the values of six parameters in real time; CO_2, PAR, soil temperature (Tsoil), air temperature (Tair), Aux (Analog Out), and soil moisture (Msoil).
Process Screen	Depending on the probe type, different information will be displayed. CO_2 will always be displayed.

Settings Screens

The Settings screens are interactive and allow the user to make changes to a number of EGM-5 settings.

Note: For this to work properly, the EGM-5 needs to be configured with Host set to WiFi (Main > Settings > Settings 3 > Port). Also, the Host Measure Interval should be 0 (Main > Settings > Settings 3 > Host).

Below is the first Setting screen, the Zero screen, which is similar to the Zero Settings screen in the user display of the EGM-5. Refer to the Setting Screens table below.

Setting Screens	
Zero Screen	Change/view the settings of the zero parameters (zero type and time interval for performing zeros).
Alarms Screen	Change/view the high and low alarm settings.
Flow Screen	Change/view the pump power and view the flow rate.
Avg Limit Screen	Change/view the CO_2 averaging method used by the EGM-5, as well as the CO_2 Averaging Limit.
About Screen	View the serial and version numbers of the hardware and software.
Advanced Screen	Allows the user to send and receive commands directly to and from the EGM-5 device.
WiFi Screen	Password protected screen to allow IT to access Lantronix WiFi parameters.
Lantronix Screen	This screen is for IT purposes to set up the network configuration of the Lantronix WiFi component.

Communication Summary

The following table summarizes the communication methods and protocols described in the preceding sections. In addition, other capabilities exist within the WiFi option that may be useful to some users attempting to write custom code on a wireless connection – please contact PP Systems for more information.

Connection to EGM-5	Typical Distance	Receiving Device	Software	Result
USB	0-2 meter	Any USB host device (PC, laptop, tablet)	Any terminal emulation program such as HyperTerminal or PuTTY	Data strings displayed in real time, Able to change EGM-5 settings with simple command strings
		Any Windows XP and above computer with a USB host port	PP Systems GAS (Gas Analysis Software)	Graphical display of data, and data logging
		Any USB host device	Custom user code	Custom interface to user equipment or data loggers
Wireless (WiFi) – Soft Access Point (no router required)	0-15 meter	Any wireless device with a browser (PC, tablet, iPhone, Android)	Any browser (Internet Explorer, Firefox, Chrome, Safari)	View EGM-5 web pages with live data and trend. Able to change wireless settings.
Wireless (WiFi) – Client Mode (EGM-5 connected to LAN via existing router)	LAN extent	Any device on the LAN with a browser (PC, tablet, iPhone, Android)		
Wireless (WiFi) – Client Mode (EGM-5 connected to LAN via existing router, AND the router firewall is configured to allow external access)	Worldwide	Any device in the world with a browser		

Notes: Highlighted blocks are the methods that most customers typically use.

Wireless Network Settings

The EGM-5 Wi-Fi embedded device server contains two network interfaces. The Software-enabled Access Point interface (SoftAP) is called ap0, and the wireless local area network interface (WLAN) is called wlan0.

A maximum of four clients can be connected to the SoftAP interface if the WLAN interface is disabled. If the WLAN interface is enabled a maximum of three clients may be connected to the SoftAP.

The wireless network settings show the status of the SoftAP or the WLAN interface/link and let you configure the settings on the device. Interface settings are related to the configuration of the IP and related protocols. Link settings are related to the physical link connection, which carries the IP traffic.

Note: All network settings require a reboot to take effect. Wait a minimum of 20 seconds after rebooting the unit before attempting to make any subsequent connections. (Reboot the WiFi hardware from Wireless Settings > Device > Reboot, or just power cycle the EGM-5.)

Connecting To EGM-5 via Direct Wireless Connection

Connecting to the SoftAP is the easiest way to interact with the EGM-5 wirelessly. In this mode, the EGM-5 acts as an Access Point for a wireless device, and no other equipment is required. This is also the default connection method enabled after a factory reset, and users must use this connection mode to change the settings for other modes.

1. By default the SoftAP mode is enabled with a default SSID of 'EGM5'.
2. Ensure that WiFi Power is turned on.
3. Use the Wi-Fi Connection Manager of your connecting device (phone, tablet, laptop, etc.) to scan for available wireless networks, and above SSID should be presented as a choice. Select the SSID and follow the device connection manager instructions. (Note: if more than one EGM-5 is powered on within the wireless range of one another, and each EGM-5 defaults to the SSID of 'EGM5', it will be difficult to determine which EGM-5 is connected to the wireless device. When more than one EGM-5 is to be used, it is recommended to power on only one EGM-5 at a time at first, then change the SSID (described in step 9) to a unique name.)
4. The default encryption mode for SoftAP is WPA2, and the passphrase is 'PPSYSTEMS'. These defaults can be changed through the configuration web manager after the initial connection has been established.
5. When prompted, enter the passphrase to complete the Wi-Fi connection authentication process. With a Wi-Fi client set to the above parameters, your device can connect directly to the EGM-5 Wi-Fi SoftAP.
6. Open a standard browser (e.g., Internet Explorer®, Firefox®, Chrome™, Safari® etc.) and enter '192.168.0.1' in the address bar. Some browsers interpret that address as a search term rather than a LAN IP address, so enter 'http://192.168.0.1' in the address bar if necessary.
7. When prompted, enter username 'admin' and password 'PASSWORD' to access the EGM-5 Web pages. The EGM-5 Splash Screen will be displayed. Click the **Main** button to advance to the 3 data screens of EGM-5, where data is continually updated by the instrument.
8. To change any of the wireless network settings, go to web management page **Settings > Yes > Advanced > WiFi > Password**
9. Select **Network > ap0 > Link** to get to the **Status/Configuration** page for the SSID, Security Suite Type and Security and passphrase settings. Modification to any of these parameters requires first pressing the **Configuration** button, then a reset/power cycle of the module in order to take effect.

It is recommended that you record any changes you make.

SSID: _____

Security Suite: _____

**Encryption:** _____

Passphrase: _____

Connecting to EGM-5 via a Local Area Network

The following steps will allow the EGM-5 to connect to an existing router or wireless access point and enable connections over a Local Area Network (LAN). Once the EGM-5 is connected to a LAN, any computer or wireless device that is also connected to that LAN can view the EGM-5 web pages.

1. Connect to the EGM-5 using the SoftAP method (described above) from any wireless device. Then navigate to the Wireless Network Settings (**Main > Settings > Yes**).
2. Select **WLAN QuickConnect:** QuickConnect offers the ability to configure the STA (WLAN Client) interface on EGM-5 WiFi to establish a connection with an active Access Point. QuickConnect obtains most of the connection properties from the Access Point and prompts the user only for the security parameters. The settings are then saved under a WLAN profile so that connecting to the same network again will be done automatically.
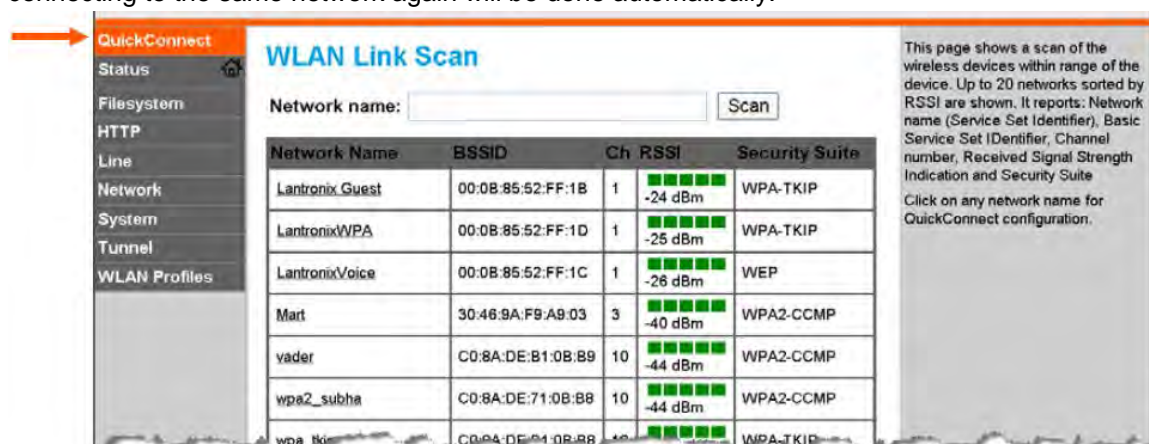
3. Upon selection of the QuickConnect option, the EGM-5 Wi-Fi scans and displays up to 20 wireless networks, sorted by signal strength. Click on a network name to view the connection details for that particular Access Point.
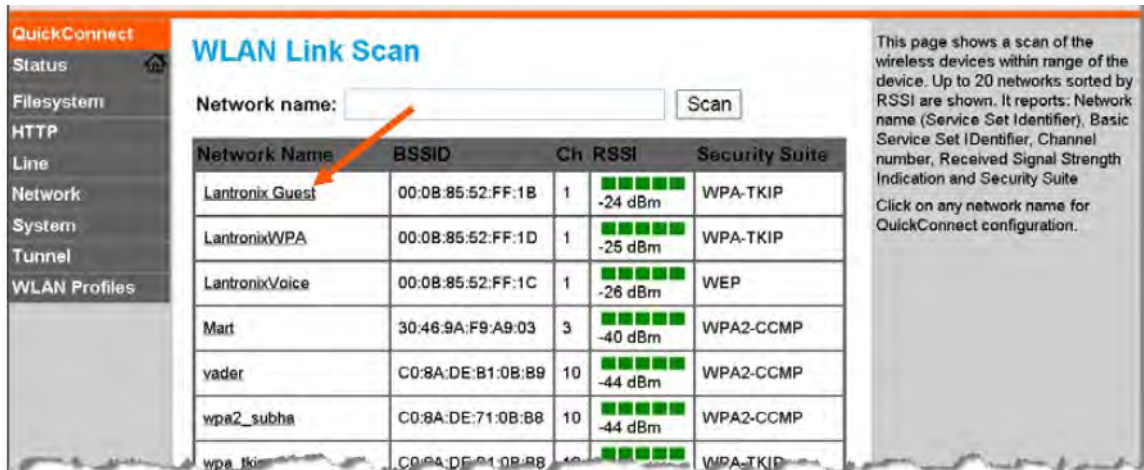
4. After selecting the Access Point you wish to connect to, enter the password and click **Submit**. The EGM-5 will connect to the network, and the profile and configuration details will be saved under WLAN profiles.
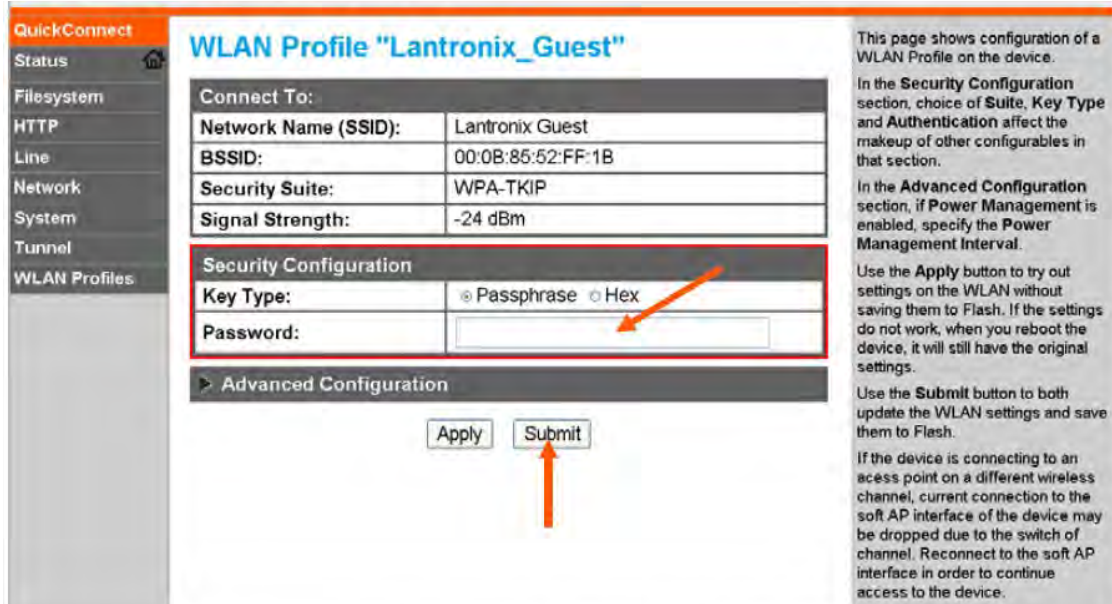
5. Once added, the QuickConnect profile will display the current connection details, which can be configured through the WLAN Profiles menu.
6. Once the EGM-5 is successfully connected a LAN, view the **Status** page under the **Interface wlan0** section to see the IP address that was assigned to the EGM-5. In the example below, the LAN IP address 10.0.0.113 was assigned to the EGM-5 (and the SoftAP **Interface ap0** address is still available for direct connection at 192.168.0.1). The LAN-assigned IP address may be periodically reset by the LAN router, but the ap0 address will always be 192.168.0.1.

EGM-5 CO2 Analyzer	
Product Information	
Product Type:	xPicoWifi
Firmware Version:	1.4.0.0A9
Build Date:	May 4 2015 (11:21:35)
Serial Number:	0080A3948023
Uptime:	0 days 00:30:28
Permanent Config:	saved
Network Settings	
MAC Address:	00:80:A3:94:80:23
Interface ap0	
State:	Up
SSID:	EGM5-R-D-1234
Security Suite:	WPA2
IP Address:	192.168.0.1/24
Interface wlan0	
Connection State:	Connected
Radio Firmware Version:	2.4.1
Active WLAN Profile:	ppsystemsap
IP Address:	10.0.0.113/24
Default Gateway:	10.0.0.1
Hostname:	EGM5
Primary DNS:	10.0.0.3
Secondary DNS:	0.0.0.0

7. Now, any computer on the LAN can open a standard browser (e.g., Internet Explorer®, Firefox®, Chrome™, Safari®) and enter the EGM-5 IP address in the address bar. Some browsers may interpret that address as a search term, rather than a LAN IP address, so begin the address with 'http://' if necessary (e.g., 'http://10.0.0.113'). Then follow steps 6, 7, and 8 from the SoftAP section above to login and navigate through the EGM-5 web pages.

Error Messages

Error and status messages are displayed in the Status Box during system operation. The following table highlights the most common messages that you may see.

Error Code	Status Box Message	Description
Error Messages		
10	Low Zero	A/D values from the last Zero are too low (<2500).
11	Low Alarm	Measured CO_2 is less than the low CO_2 setting (250 ppm by default).
12	High Alarm	Measured CO_2 is greater than the high CO_2 setting (2000 ppm by default).
13	Under Temp	Analyzer temperature < 50 °C.
14	Over Temp	Analyzer temperature > 60 °C.
15	Low Flow	Sample flow rate is less than 50 cc/min.
16	IRGA Write	IRGA unable to perform a write operation. If error persists, call PP Systems technical support.
17	IRGA CRC	IRGA read/write EEPROM CRC incorrect. If error persists, call PP Systems technical support.
18	IRGA Range	IRGA setting error. Value is out of range. If error persists, call PP Systems technical support.
19	CO_2 limit	Reached Process CO_2 limit
20	Time limit	Reached Process time limit
21	Non Linear	The SR measurement is Non Linear
22	End Process	The process has been terminated
23	Absorber used	The Absorber column material has been exhausted and needs replacing
24	Zero 2 min	Zero will occur in 2 minutes
25	Zero 1 min	Zero will occur in 1 minutes
26	IRGA DigiPot	Could not successfully write the IRGA DigiPot
30	Unknown CMD	Host only. First character is not recognized as a command.
31	Invalid Format	Host only. First character is a recognized command but the next character is invalid. Example: S1,1<CR> (as opposed to S,1,1<CR>.
32	Invalid Param	Host only. Command is correct but parameter is not valid. Example: S,20,5. The value of 20 is an invalid parameter.
33	Low Limit	Host Only. Value entered is below the valid range of values for that parameter.
34	High Limit	Host Only. Value entered is above the valid range of values for that parameter.
50	No Memory	No flash drive detected.
51	Memory CF	Flash drive error. Command failed – Filename or directory name not found.
52	Bad Record	Flash drive error. Bad command – Command not recognized.
53	Memory Full	Flash drive full – No free space on disk.
54	Memory FI	Flash drive error. Invalid – Attempt to open a directory for reading or writing. Attempt to change currently selected directory to a file.
55	Memory RO	Flash drive error. Read only – Attempt to open a read only file for writing.
56	File Open	Flash drive error. File open – A file is currently open for writing and must be closed before this command can be executed.

| 57	Memory NE	Flash drive error. Directory not empty – Attempt to delete a directory which is not empty.
58	Memory FN	Flash drive error. Filename invalid – Firmware invalid or contains disallowed characters.
60	Memory NU	Flash drive message. No upgrade – Firmware upgrade file not found on disk. This message is displayed each time a disk is inserted into the drive.
61	Mem Detected	Flash drive message. Disk detected - This message should be displayed each time a disk is inserted into the drive.
62	Mem Removed	Flash drive message. Disk removed - This message should be displayed each time a disk is removed from the drive.
63	No Memory	The UART Buffer for the flash drive is Full. Flash drive file too large. (slow to update) Use new flash drive or delete files.

Maintenance

The EGM-5 requires minimal maintenance. There should be no need to open the enclosure to access internal components (e.g., battery, pump, IRGA, etc.). The two most common items requiring periodic inspection and maintenance include:

- External air filter
- Absorber column and desiccant

Both of the above items are external to the EGM-5 and easy to service and maintain.

External Air Filter

An external air filter should be used at all times and fitted in-line with the GAS IN port on the EGM-5 to protect internal components from dirt and dust (see below). The main assembly (STD558) should not require replacement unless it is broken or missing. You can purchase replacement filters (STD556) for use with the main assembly if required.
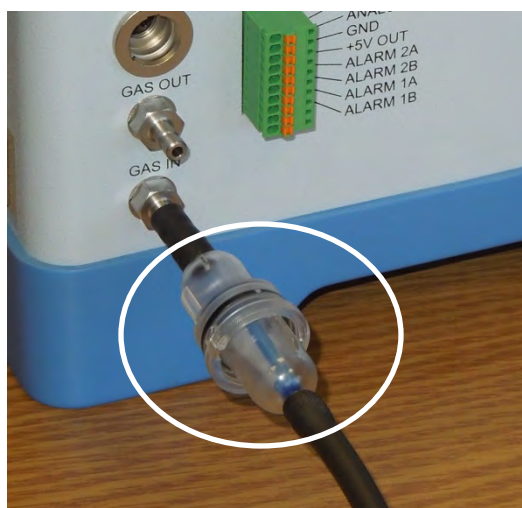

When changing out filters you should put a slight smear of silicone grease on the "O" ring which provides a good seal on the filter.

Re-Order Information	
Part Number	**Description**
STD558	External Inlet Air Filter Assembly (Complete)
STD556	Replacement Filter Element, 48 um (Blue)

Absorber Column and CO$_2$ Scrubber

The absorber column is located on the rear of the EGM-5 enclosure. It can easily be removed from the instrument by gripping it around the middle of the column and gently pulling it out of its manifold.
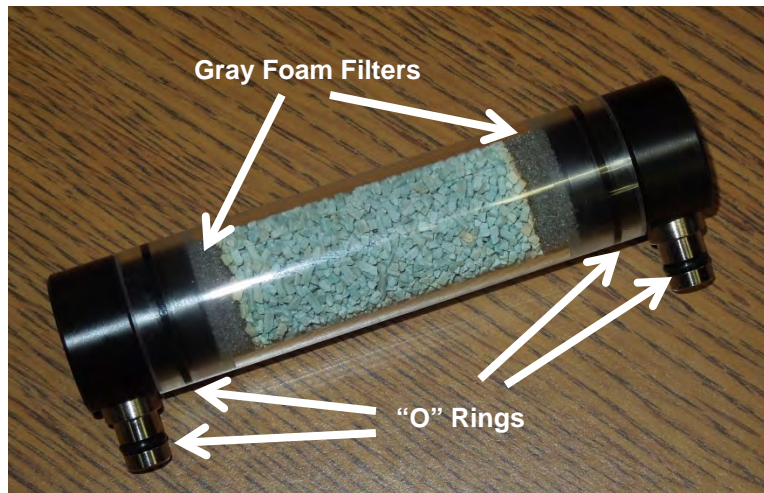
Periodically inspect the following:

Gray Foam Filters

The gray foam filters used inside the absorber column (top and bottom) will wear over time and should be inspected regularly and replaced when torn or reduced in size. The foam must be of an open celled type, such as packing foam. The foam filters at the bottom of each column will likely require more frequent changes versus the upper foam filters.

Absorber Filters

Each absorber end cap contains a white plastic filter disk. Generally these do not need to be replaced but should be checked periodically. However, they must be present to prevent any of the column contents being drawn with the gas stream causing damage to the instrument.

End Cap "O" Rings

Each end cap has two "O" rings, one that seals inside the plastic column and another that seals at the manifold. All "O" Rings on the absorber column should periodically (every couple of weeks) receive a slight smear of silicone grease to aid ease of fitting, improve the seal and extend the life of the "O" rings and to keep them from cracking or breaking. Once sealed, end fittings should be checked to ensure that the O-rings are seated correctly in their groove and that they are not trapped or pinched resulting in system leaks.

Soda Lime (CO$_2$ Scrubber)

Soda lime is used as a CO$_2$ scrubber and it will exhaust over time. Soda lime can be "self-indicating" or "non-indicating". Both types work with the EGM-5. If using "self-indicting" Soda lime it is best to change when it is 2/3rds exhausted. If using "non-indicating" Soda lime you should be more cautious and change it out when the CO$_2$ scrubber percentage reaches 20% or less (See Soda Lime (CO$_2$ Scrubber) on page 24.

Soda Lime cannot be regenerated and should be discarded after exhaustion.

At present, PP Systems supplies the following type of soda lime desiccant:

- Type: Sofnolime®, 1.0-2.5 mm, self-indicating (white to violet), 1 kg
- Manufacturer: Molecular Products. (www.molecularproducts.com)
- For the latest Material Safety Data Sheet, please visit www.molecularproducts.com and request the latest MSDS or contact PP Systems.

For the latest MSDS on alternative types of soda lime, please contact the manufacturer directly or contact PP Systems.

**Take caution to wash your hands completely after handling soda lime**

Re-Order Information

| Part Number	Description
10164-1	EGM-5 Absorber Column (Complete)
20041-2	Absorber Column (clear plastic only)
41508-1	Gray Filter Foam
30013-1	O-ring 4.47 x 1.78
30013-17	O-ring 17.6 x 2.4
STD007W	Sofnolime (white to violet), 1.0 kg

Access to Internal Components

Under most circumstances there should be no need to service internal components (pump, IRGA, hydrophobic filter, solenoid, battery, etc.). However, in the event that you do need to troubleshoot and examine these items you can gain access into the EGM-5 enclosure by removing the 8 screws securing the base to the main enclosure as shown below.
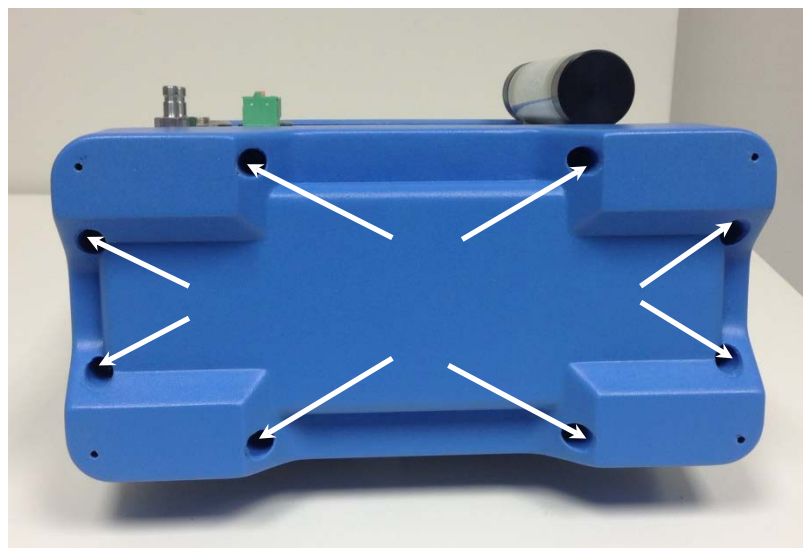
Gently remove the base from the upper enclosure as shown below:

Battery connector

Battery
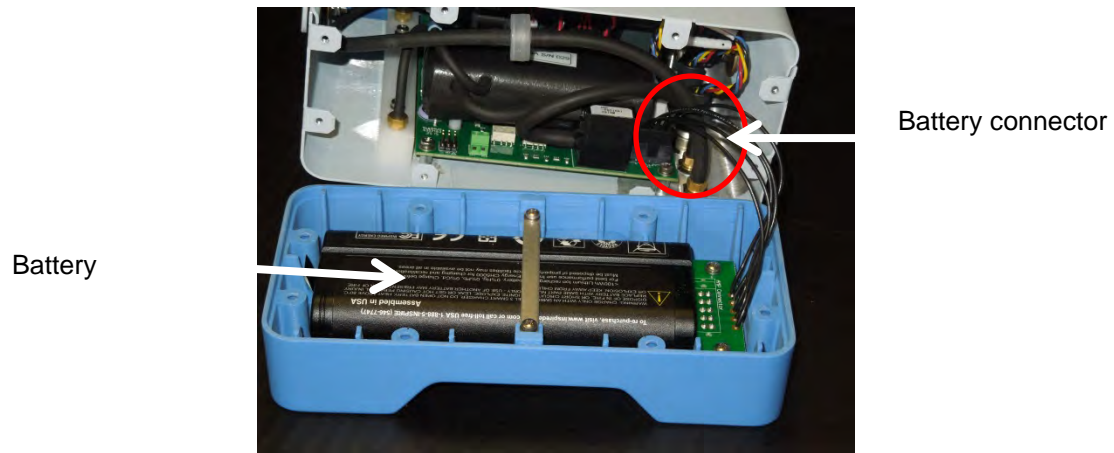
If you need to gain access to the internal PCB that includes the pump, IRGA, and hydrophobic filter, you will need to remove two more screws that secure the aluminum enclosure to the top panel, as highlighted below in the red circles:
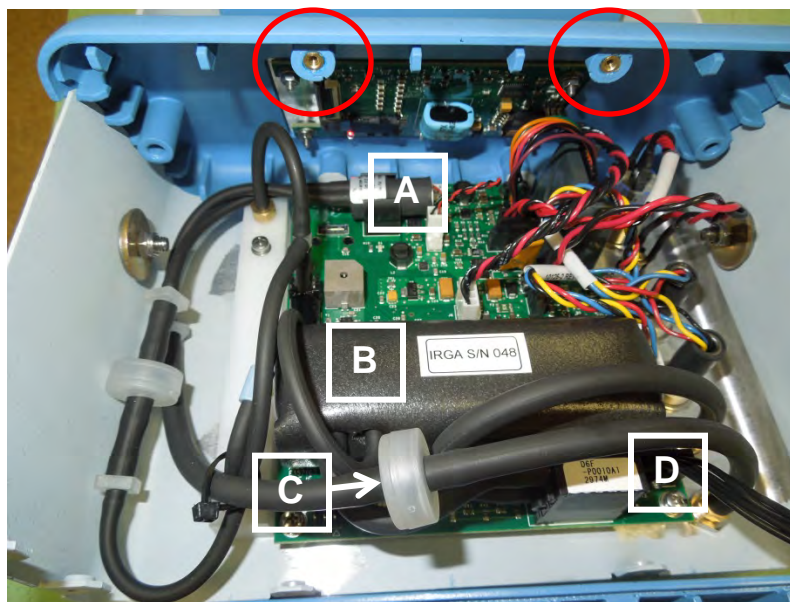
A. Air Sampling Pump
B. IRGA (Optical Bench)
C. In-line Hydrophobic Filter
D. Battery electrical connection

Sampling Pump

The sampling pump used in the EGM-5 is a rotary vane style pump. It is secured in place by a simple mounting clip and is electrically connected to the PCB at location J13 (4-pin header). It operates from 1.0 – 5.0 VDC, which is generated by the EGM-5 controller board. It is capable of delivering flow rates up to 500 cc/min flow. History has shown that this type of pump is rugged and durable and should last for many years. If replacement is necessary, please contact PP Systems.

Re-Order Information	
Part Number	**Description**
10181-1	Miniature Rotary Sampling Pump

Infrared Source

The infrared source should last for many years without replacement. The obvious sign of failure is that it is not flashing when the system is powered. It is preferable to return the instrument to PP Systems for full factory recalibration after changing a failed source lamp. However, if that is not possible, a few checks can be made to ensure that the analyzer is working properly after changing a source lamp in the field. Please contact PP Systems for more information.

Hydrophobic Filter

There are two internal hydrophobic filter located inside the EGM-5 enclosure. They are both secured in place by black Viton tubing. Neither should require frequent replacement unless you are working in extremely high humidity conditions. If you are regularly seeing "low flow" messages, or if you are unable to achieve flow rates greater than 50 cc/min, then the "In-line" hydrophobic filter should be replaced. Simply remove the filter from the tubing and replace it with a new one.

Re-Order Information	
Part Number	**Description**
10045-1	Hydrophobic Filter

Battery

The internal, rechargeable Li-Ion battery pack should last for many years. When fully charged it should allow continuous operation of the instrument up to 16 hours. We recommend that you always fully recharge the battery after use. If the instrument is stored for longer periods, ensure that the battery is fully charged prior to storage.

Re-Order Information	
Part Number	**Description**
41535-1	7.5V Li-Ion Battery

Appendix 1. Soil CO$_2$ Efflux and Net Canopy CO$_2$ Flux

The **SRC-2 Soil Respiration Chamber** can be used with the EGM-5 Portable CO$_2$ Gas Analyzer for closed system measurement of soil CO$_2$ efflux. The **CPY-5 Canopy Assimilation Chamber** can also be used with the EGM-5 for closed system measurement of net canopy CO$_2$ flux**.**

Theory

The respiration (or assimilation) is measured by placing a closed chamber on the soil and measuring the rate of increase of the CO$_2$ concentration inside the chamber.

(1.1) Then, assuming a well-mixed and sealed system:

$$F_{CO_2} = \frac{(Cn - Co)}{T_n} \times \frac{V}{A}$$

Where:

F_{CO_2} = respiration/assimilation rate (CO$_2$ flux in moles or grams of CO$_2$ unit area^{-1} unit time^{-1})

Co = is the CO$_2$ concentration at T = 0

Cn = is the concentration at a time T_n later

A = is the area of soil exposed

V = the total system volume

It has been suggested that to make accurate measurements of the respiration it is essential to start with a CO$_2$ concentration in the chamber below ambient and measure until the concentration is above ambient, presumably with the intention of getting some compensation for leakage. However, this leakage can only take place at ground level, where the CO$_2$ concentration is unknown and most certainly will not be what we would consider as ambient.

Over the short period of measurement and with the relatively small CO$_2$ concentrations in the chamber compared with the soil concentrations, we would expect the assimilation to be a constant flux, giving a constant rate of change in the chamber CO$_2$ concentration.

Any leakage should be a function of the concentration difference between the chamber and the exchange air. Due to leakage, the apparent assimilation rate decreases with time. So leakage would have the effect of changing the ideal linear C vs T relationship to a non-linear relationship.
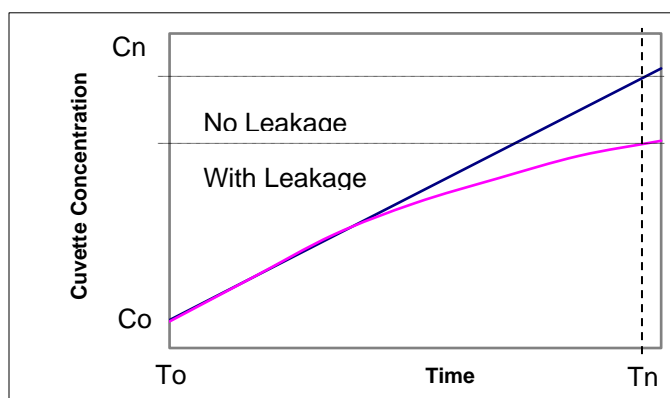
Soil Respiration Measurements

The EGM-5 software assumes a quadratic relationship (y = a + bx + cx^2) between the chamber concentration (C=y) and time (T=x) from the start of measurement to account for the non-linearities caused by leakage. Note that there is a delay after the chamber is first placed on the soil to allow for the establishment of stable gradients before the measurements begin.

(1.2) The quadratic equation is

$$C = a + bT + cT^2$$

Where C and T are a series of chamber CO_2 concentration measurements made over time, and a, b, c are coefficients calculated from a least square fit of the data.

The respiration rate will be calculated from the rate of change of CO_2 at time zero or dC/dT at T=0.

(1.3) Differentiating equation **(1.2)** yields

$$\frac{dC}{dT} = b + 2cT$$

(1.4) And evaluated at T = 0,

$$\frac{dC}{dT} = b$$

A comparison of b and cT gives an indication of the magnitude of the non-linearity of the C vs T data. The EGM-5 software indicates a "non-linear" error message whenever the value cT is greater than 20% of b. This is believed to be a better approach than lowering the CO_2 value at the start of the measurement.

In addition to the quadratic assumption and calculation, the EGM-5software also calculated the respiration (or assimilation) using a linear assumption.

(1.5) The linear equation is

$$C = a + bT$$

(1.6) which evaluates again to

$$\frac{dC}{dT} = b$$

In this case the value of dC/dT is calculated from a linear regression of the C and T data.

Correction for water vapor increase on CO_2 efflux

In addition to the influx of CO_2 from soil, a closed chamber system can also experience an increase in H_2O due to evapotranspiration from soil or plants. This added H_2O dilutes the remaining CO_2 and requires a compensation in a similar way to equation **(A.13)**.

For total moles of air in the chamber of W,

(1.7) the moles of H_2O added to the chamber is $E = \frac{(e_{final} - e_{init})}{(1000 - e_{final})}$,

where e_{init} and e_{final} are H_2O concentrations in mmol mol^{-1}.

The initial moles CO_2 in the system $= C_{init} \times W$, where C_{init} is CO_2 concentration in mol mol^{-1}.

Then, the final moles CO_2 in the system $= C_{final} \times (W + E)$, where C_{final} is CO_2 concentration in mol mol^{-1}.

(1.8) The change in moles of CO_2 is $(C_{final} \times (W + E) - (C_{init} \times W) = (C_{final} - C_{init})W + C_{final} E$

The term $(C_{final} - C_{init})W$ is equivalent to the dC/dT term calculated above, and the $C_{final} E$ term is the correction due to evapotranspiration.

(1.9) So, with the H_2O compensation, we have

$$\frac{dC}{dT} = b + C_{final}\left(\frac{e_{final} - e_{init}}{1000 - e_{final}}\right)$$

where b can be either from the quadratic or linear fit.

FCO$_2$ Units for measurement of Soil CO$_2$ Efflux

(1.10) To give the CO_2 flux in mass/unit area/unit time the following conversion is made:

$$F_{CO2}(\text{g m}^{-2}\text{hr}^{-1}) = \frac{dC}{dT}\frac{\mu\text{mol}}{\text{mol s}} \times \frac{P}{1013} \times \frac{273}{273 + T_{air}} \times \frac{44.009 \text{ g}}{22.414 \text{ L}} \times \frac{V \text{ m}^3}{A \text{ m}^2} \times \frac{\text{mol}}{10^6 \text{ }\mu\text{mol}} \times \frac{3600 \text{ s}}{\text{hr}} \times \frac{10^3\text{L}}{\text{m}^3}$$

Where

dC/dT is from eqn 1.9 from linear or quadratic fit and with H_2O compensation

$\frac{P}{1013}$ is the correction for barometric pressure with P measured in mbar by the EGM-5,

$\frac{273}{273+T_{air}}$ is the correction for air temperature with T_{air} input by the user in ºC,

$\frac{44.009 \text{ kg}}{22.414 \text{ m}^3}$ is the molar volume and Ideal Gas constant at STP,

$\frac{V \text{ m}^3}{A \text{ m}^2}$ is the chamber volume and soil surface area,

And the remaining terms are units conversions.

(1.11) The same equation in alternate units is

$$F_{CO2}(\mu\text{mol m}^{-2} \text{ s}^{-1}) = \frac{dC}{dT}\frac{\mu\text{mol}}{\text{mol s}} \times \frac{P}{1013} \times \frac{273}{273 + T_{air}} \times \frac{1 \text{ mol}}{22.414 \text{ L}} \times \frac{V \text{ m}^3}{A \text{ m}^2} \times \frac{10^3\text{L}}{\text{m}^3}$$

Or to convert (g m^{-2} hr^{-1}) to (μmol m^{-2} s^{-1}) multiply $F_{CO2}(\text{g m}^{-2}\text{hr}^{-1})$ by 6.312.

References
Parkinson K.J. (1981). An improved method for measuring soil respiration in the field. Journal of Applied Ecology, 18, 221-228.

Appendix 2. WiFi Compliance

The optional WiFi device used in the EGM-5 is the xPico® Wi-Fi® Embedded Device Server by Lantronix.

(According to the ISO/IEC Guide and EN 45014)

Manufacturer's Name & Address:

Lantronix, Inc.
167 Technology Drive, Irvine, CA 92618 USA

Declares that the following product:

Product Name Models:

xPico® Wi-Fi® Embedded Device Server, xPico Wi-Fi SMT Embedded Device Server Conforms to the following standards or other normative documents:

Table C-1 Country Certifications

Country	Specification for xPico Wi-Fi Model	Specification for xPico Wi-Fi SMT Model
USA FC	◆ FCC Part 15, Subpart B, Class B ◆ ICES-003:2012 Issue 5, Class B ◆ ANSI C63.4-2009	◆ FCC Part 15, Subpart B, Class B ◆ ICES-003:2012 Issue 5, Class B ◆ ANSI C63.4-2009
USA	◆ FCC Part 15, Subpart C (Section 15.247) ◆ ANSI C63.10-2009 ◆ FCC Part 2 (Section 2.1091) ◆ FCC OET Bulletin 65, Supplement C (01-01) ◆ IEEE C95.1	◆ FCC Part 15, Subpart C (Section 15.247) ◆ ANSI C63.10-2009 ◆ FCC Part 2 (Section 2.1091) ◆ FCC OET Bulletin 65, Supplement C (01-01) ◆ IEEE C95.1
Canada	◆ Canada RSS-210 Issue 8 (2010-12) ◆ Canada RSS-Gen Issue 3 (2010-12) ◆ ANSI C63.10-2009 ◆ RSS-102 Issue 4 (2010-12)	◆ Canada RSS-210 Issue 8 (2010-12) ◆ Canada RSS-Gen Issue 3 (2010-12) ◆ ANSI C63.10-2009 ◆ RSS-102 Issue 4 (2010-12)
EU	◆ EN 300 328 V1.8.1 (2012-06) ◆ EN 301 489-1 V1.9.2 (2011-09) ◆ EN 301 489-17 V2.2.1 (2012-09) ◆ EN 55022:2010+AC:2011, Class B ◆ EN62311:2008	◆ EN 300 328 V1.8.1 (2012-06) ◆ EN 301 489-1 V1.9.2 (2011-09) ◆ EN 301 489-17 V2.2.1 (2012-09) ◆ EN 55022:2010+AC:2011, Class B ◆ EN62311:2008
Australia, New Zealand N11206	◆ AS/NZS 4268: 2012	◆ AS/NZS 4268: 2012
Japan	◆ ARIB STD-T66, MIC notice 88 Appendix 43 ◆ RCR STD-33, MIC notice 88 Appendix 44	◆ ARIB STD-T66, MIC notice 88 Appendix 43 ◆ RCR STD-33, MIC notice 88 Appendix 44

Table C-2 Country Transmitter Ids

Country	Specification for xPico Wi-Fi Model	Specification for xPico Wi-Fi SMT with U.FL Model	Specification for xPico Wi-Fi SMT with Antenna Model
USA FCC ID	R68XPICOW	R68XPICOW	R68XPICOW
Canada IC ID	3867A-XPICOW	3867A-XPICOW	3867A-XPICOW
Japan ID	201-135275	201-135275	201-135275

Table C-3 Safety

Country	Specification for xPico Wi-Fi Model	Specification for xPico Wi-Fi Model with Antenna
World Wide C€0560	CB EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011 In accordance with the council directive 2006/95/EC	CB EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011 In accordance with the council directive 2006/95/EC
US, Canada	UL 60950-1 (2nd Edition)	UL 60950-1 (2nd Edition)

Hereby, Lantronix, declares that this xPico Wi-Fi and xPico Wi-Fi SMT embedded device server is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/ EC.

Federal Communication Commission Interference Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.