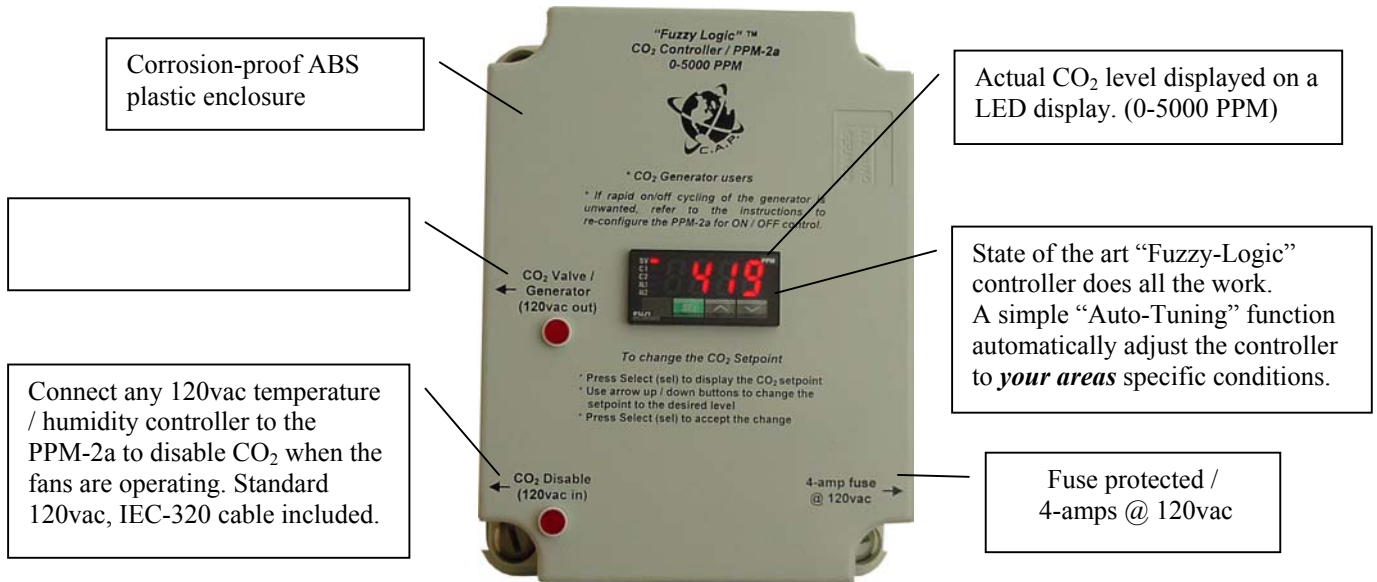


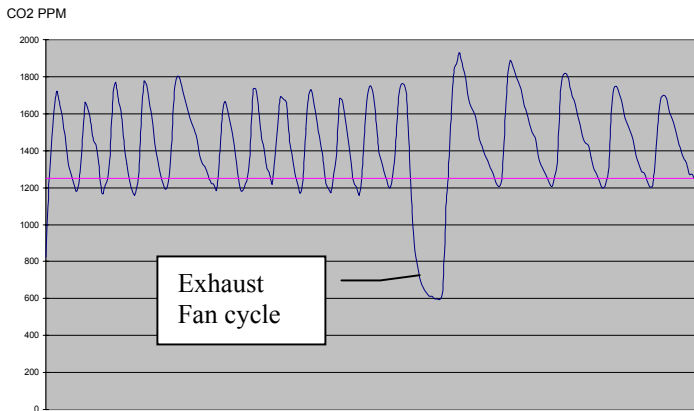


PPM-2a / Fuzzy Logic™ CO₂ Controller

CAP's newest CO₂ controller, the PPM-2a is the most efficient CO₂ controller that has ever been created... What set's the PPM-2a apart from the competition? **Fuzzy logic!** Fuzzy Logic can be compared to a good driver. As a good driver approaches a red light, he or she applies the brakes to gradually slow down *BEFORE* getting to the intersection. Fuzzy Logic uses the same idea to bring the CO₂ level up to the desired setting, without going over the set point.

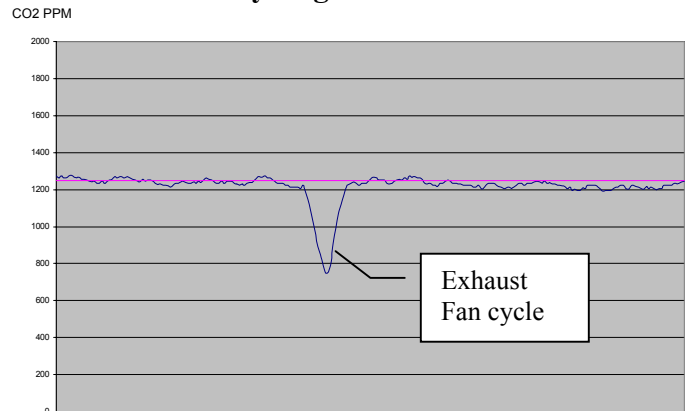


ON / OFF control



Standard on / off controllers do not anticipate when to shut off the CO₂ in order to avoid "overshooting" the set point. This is because on / off control does not allow time for the CO₂ to "mix" with the air, it simply keeps pumping more and more CO₂ in until the PPM meter finally reacts to the increase in level. While this might be fine when using a CO₂ generator which costs very little to run, it is not efficient when using bottled CO₂ which has a much higher cost.

Fuzzy Logic™ CO₂ control



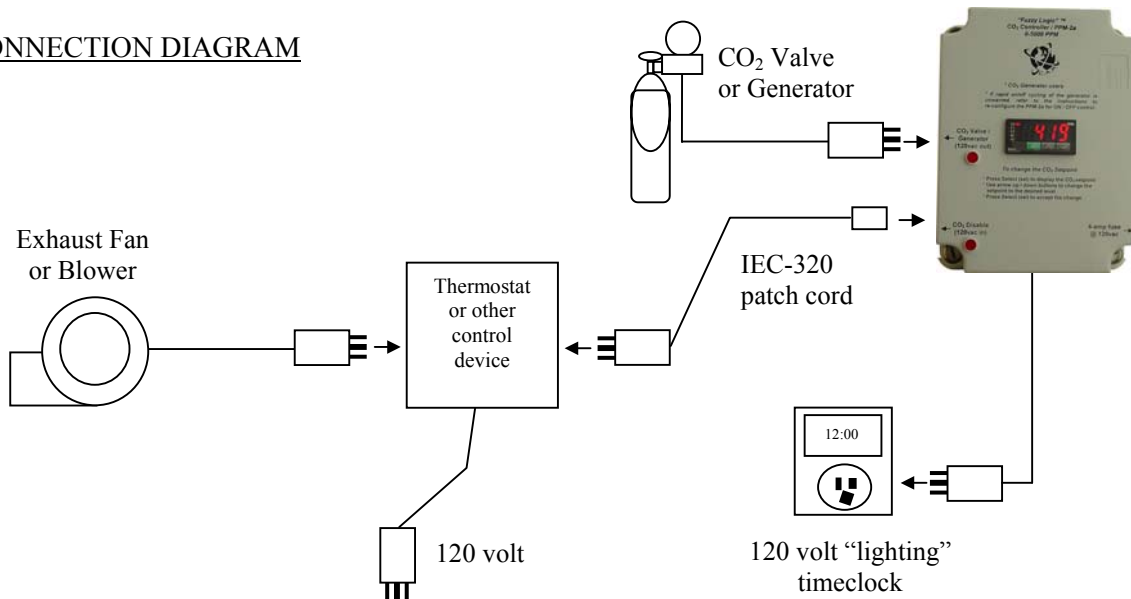
The PPM-2a's **Artificial Intelligence** (Fuzzy Logic) behaves as though you have a trained operator in your growing area to monitor the CO₂ level and release more CO₂ only when required. PPM-2a users can expect to have their CO₂ level kept within 25PPM of their desired set point. The PPM-2a automatically "learns" how to best maintain the set point as it operates. This will result in a huge savings when using compressed CO₂ gas compared to standard on / off controllers.

*Testing took place inside an 8' x 8' room with a 15cfm fan running throughout the test to simulate room "leakage". A 165cfm fan ran for 5 minutes during the test to simulate a cooling cycle. The controllers were set at 1250PPM. An Extech #383273 data-logging multi-meter continuously monitored the CO₂ level and recorded sample readings every 30 seconds for 2 ½ hours. It is easy to see why the flat line performance of the Fuzzy Logic is far superior to on / off controllers in reducing wasteful "over-shoot".

INSTALLATION & START-UP

- 1) Find a location at plant level near the center of the area to be controlled. Provide proper circulation throughout the area to be controlled and directly around the PPM-2a. DO NOT place the PPM-2a near sources of moisture. If water is allowed to enter the ventilated enclosure, the sensor may be affected. DO NOT expose the unit to direct sunlight.
- 2) The PPM-2a comes pre-wired with an 18-24 volt “plug-in” power supply and 120vac power cord. The 18-24 volt POWER SUPPLY must be connected to a constant source of 120vac power. The power cord should be connected to your lighting timer to control CO₂ only during the “DAY”. It can also be plugged into a separate timer if you want the CO₂ to be up to the desired level BEFORE the lights are turned ON.
- 3) Once powered up, the PPM-2a will enter a warm-up and calibration mode. Slowly, over a 10 to 15-minute period, the level should drop to approximately 400 PPM outdoors and as much as 900 PPM indoors. Do not breathe directly on the unit. As you exhale, you release CO₂ which will affect the reading dramatically.
- 4) People who are operating a CO₂ generator may want to change the PPM-2a to operate as an ON / OFF controller. In some cases, the PPM-2a will “pulse” the CO₂ device ON & OFF rapidly in an attempt to control the CO₂ level to a very accurate level. When operating generators, that type of accuracy may not be needed due to the reduced cost of running a generator as compared to compressed CO₂. Activating the ON / OFF control mode will eliminate excessive “wear & tear” of the CO₂ generators solenoid valve. Changing the PPM-2a over to an ON / OFF controller is fairly easy. Refer to the “Changing Control Modes” section for more information.
- 5) If you are using “open-loop” ventilation with exhaust fan(s) to cool the area, the CO₂ Disable function can be used. CO₂ Disable prevents the CO₂ valve or generator from working when the fans are operating. The PPM-2a comes complete with a standard 120-volt “IEC-320” power-patch cord that can be plugged into whatever device is being used to operate the exhaust fans. When the fans turn ON... the CO₂ is turned OFF.
- 6) If you are using a “closed-loop” cooling system such as an air conditioner, it is not necessary to connect the CO₂ Disable cord. Most areas have a certain amount of “seepage” no matter how tight the area is sealed. If your temperature and humidity is kept at the proper levels, it is not critical to expel or exchanged the air in the area unless you are operating a CO₂ generator in an area, which has been sealed well.

CONNECTION DIAGRAM



“CO₂ DISABLE”

The CO₂ Disable function eliminates the possibility of releasing CO₂ while the Exhaust / cooling fans running. An IEC-320 Quick-connect cable is connected from the thermostat or other device that controls the fans, to the PPM-2a. The only requirement of the temperature / humidity controller is that it works on 120vac power. By using a splitter or power strip to connect both the fans and the CO₂ Disable cable, almost any controller, thermostat or device can be used. If nothing is connected to the CO₂ Disable, the PPM-2a will continue to maintain the level of CO₂ in the area during the entire time it is on. Once the CO₂ Disable cable is properly connected, when the exhaust fans are running, the CO₂ Disable indicator will be illuminated.

AUTO-TUNING

Every growing area has variables such as area size, fan types, ambient temperature, unique airflow characteristics, CO₂ delivery system and flow-rate. Ordinary “Part-Per-Million” controllers do not take most of these variables into consideration thus they are not very good at keeping the CO₂ at a constant level. A standard set of “parameters” which define how the Fuzzy Logic’s AI (Artificial Intelligence) is pre-programmed into the PPM-2a. For MOST applications, the standard set will work fine. In fact, most people report the PPM-2a maintains their desired set point +/- 25 PPM.

If after a few days of operating the PPM-2a you are not satisfied with the performance, you can try to allow the unit to “re-teach” itself the base parameters *FOR YOUR SPECIFIC AREA*. And that is exactly what the “Auto-Tuning” function does. When the “Auto-Tuning” function is used, the PPM-2a automatically measures your systems performance and calculates the best method to control CO₂ within the area. It then uses this information in conjunction with a simple form of *Artificial Intelligence* called “Fuzzy-logic” to give you truly exceptional efficiency.

There are four reasons to perform “Auto-Tuning”.

- 1) Unsatisfactory performance after operating the unit for a few days.
- 2) Changing the set point (SV) more than 400 PPM.
- 3) Major (and some minor) changes in the CO₂ delivery system, area configuration, fan changes, ECT.
- 4) Abnormal or inconsistent results from previous Auto-Tunings.

HOW TO PERFORM “AUTO-TUNING”

The Auto-Tuning function takes from 1½ to 2½ hours to complete. DON’T WORRY. It is completely automatic once the test is started. However, before performing an Auto-Tuning, you MUST prepare the area for the procedure. This may take at the most 15 minutes.

- 1) During the Auto-Tuning, the area must be operating normally. **Internal circulating fans must remain operating.**
- 2) **Exhaust and/or cooling fans which bring fresh air into the area must be disabled. If heat or humidity build-up is a problem during the 2-hours required, reduce the lighting or other heat loads temporarily until the test is completed.**
- 3) Set the CO₂ flow-gage to the setting most likely to be correct for your area. If no estimate is known, set it near the middle of the range and increase it if the first Auto-Tuning does not provide consistent control.
- 4) If the PPM-2a’s “CO₂ Disable” is connected to a thermostat / humidistat responsible for running the exhaust fans, disconnect the cable until the test is completed.
- 5) Close the CO₂ tank valve. Connect the CO₂ valve or generator to the PPM-2a. **There should be no CO₂ flowing out of the tank until the test is started.**
- 6) Set the SV (desired CO₂ level) to the desired level. (See Changing Set point)
- 7) Press [SEL] for 1 second. (RUN will be displayed)
- 8) Press the [Down] button one time. (AT will be displayed)
- 9) Press the [SEL] button once. (0 is displayed)
- 10) Press the [UP or DOWN] button to bring up 1. (1 is displayed)
- 11) Press the [SEL] button once. The decimal point will begin to flash until the Auto-Tuning procedure is completed. The CO₂ outlet will be energized.
- 12) Quickly open the CO₂ tank valve and verify CO₂ is flowing out of the flow-gage / regulator.
- 13) Get out of the area and do not disturb the area for a minimum of two hours. After two hours, enter the area and confirm the decimal point has stopped flashing, which indicates the test is complete.
- 14) Reconnect the Exhaust fans, CO₂ Disable cable and return the area to normal operation while monitoring the level of CO₂. Do not continue to stand next to the PPM-2a while monitoring. Just keep an eye on the display and record the level every 30 minutes or so. Try to observe the unit reacting to and recovering from the Exhaust fans operating. The level should drop down to 800PPM or less and then recover quickly without overshooting the set point more than 150 PPM.
- 15) If after operating a day or two you are not getting good consistent control, (+/- 100 PPM from set point) it may be a good idea to perform a second Auto-Tuning.

***NOTE: If your CO₂ tank runs out for a period of time, the control may take a few hours to re-stabilize, this is normal.**

CHANGING THE SETPOINT (SV)

The PPM-2a has an adjustable set point. The set point is the minimum CO₂ level in Parts-Per-Million you want to maintain. The face of the Fuzzy Logic controller has 5 led indicators on the left side of the face. The one marked (SV) is illuminated when viewing and / or changing the set point.

- 1) Press (SEL) momentarily. The SV indicator will light up and the current set point is displayed. (The PPM-2a is factory set @ 1500 PPM)
- 2) Use the (UP / DOWN) buttons to change the set point to your desired level. Normally between 1250 –2000 PPM.
- 3) Press the (SEL) button momentarily to accept the change.

CHANGING CONTROL MODES

People operating compressed CO₂ systems will definitely benefit from the PPM-2a's "Fuzzy Logic". To have the greatest degree of accuracy, the PPM-2a may "pulse" the CO₂ device ON/OFF at frequent intervals to avoid "over-shooting" the set point. This may reduce the lifetime of the CO₂ device slightly.

Some people who are using LP / Natural gas generators may want to turn down the sensitivity of the PPM-2a in order to extend the life of their generator. This can be accomplished by changing the PPM-2a's control mode from Fuzzy Logic to ON / OFF. When operating in ON / OFF mode, the rapid pulsing of the control solenoid is eliminated. A preset hysteresis (dead-band) of 50PPM still allows the PPM-2a to control the CO₂ to an average level of +/- 200 PPM. For comparison's sake, the average accuracy of the Fuzzy Logic control mode is around +/-25PPM. Follow the procedures listed below to easily change the control modes on the PPM-2a.

Changing to ON / OFF control mode

- 1) Press and hold the (SEL) pushbutton for three seconds. (**P** will be displayed)
- 2) Press the (SEL) button momentarily. (The current proportional band setting will be displayed = **5.0**)
- 3) Using the (Down) pushbutton, change the display to read (**0.0**)
- 4) Momentarily press the (SEL) button to accept the change.
- 5) Allow the unit to re-start by not touching any of the buttons for approximately 30 seconds.

Changing to "Fuzzy Logic" control mode

- 1) Press and hold the (SEL) pushbutton for three seconds. (**P** will be displayed)
- 2) Press the (SEL) button momentarily. (The current proportional band setting will be displayed = **0.0**)
- 3) Using the (Down) pushbutton, change the display to read (**5.0**)
- 4) Momentarily press the (SEL) button to accept the change.
- 5) Allow the unit to re-start by not touching any of the buttons for approximately 30 seconds.

CALIBRATION

The PPM-2a is factory calibrated. The sensor onboard the PPM-2a is capable of remaining in calibration for a minimum of five years. Extreme shock during shipping and other factors may affect the calibration. To check the calibration, follow the procedure below.

Supplying the unit with outside air can quickly verify the calibration. Depending on the environmental conditions in your area, the reading outdoors should be around 250-550PPM. Be sure to allow the PPM-2a to properly warm-up especially in cold temperatures. If the PPM-2a calibration is incorrect, the unit can be returned to the manufacturer. Please note:

- **The PPM-2a CO₂ sensor has built-in temperature compensation which automatically corrects the reading depending on the ambient temperature. However, extreme temperatures of below 20°F or above 120°F may affect the reading.**
- **Checking calibration in urban areas usually results in higher ambient CO₂ readings due to car exhaust and human activity.**

To check calibration:

- 1) Bring the unit outside so that it will receive fresh air. Do not locate the unit in direct sunlight.
- 2) Plug the power supply and power cord into 120vac.
- 3) Move away from the controller to allow the reading to stabilize for approximately 20 minutes.
- 4) Check the CO₂ level.
***Important: Do not breathe while checking the calibration the unit. As you exhale, large concentrations of CO₂ are expelled from your lungs. This higher level of CO₂ will affect the calibration of the unit. Try to hold your breath!**
- 5) If the level is between 250 and 550 the unit is performing fine. If it is outside that range, allow the unit to stabilize longer.
- 6) If the calibration is still off, the unit can be returned to the factory for calibration and re-certification.

TROUBLESHOOTING

If you are having problems with this unit, refer to these troubleshooting hints. Also, refer to the connection diagram to ensure your devices are connected properly.

<u>Problem</u>	<u>Suggested Action</u>
◆ I have no lights and no function at all.	◆ Check the fuse and main power. Check the equipment connected to the PPM-2a for problems and/or short circuits. ◆ Replace the fuse if required with the a 4-amp fuse.
◆ The CO ₂ outlet is pulsing ON and OFF too often.	◆ If you are running a CO ₂ generator, you may want to change to ON / OFF control. ◆ If running compressed CO ₂ you may want to try running an Auto tune.
◆ After my compressed bottle or LP tank was replaced, the level fluctuates.	◆ If your CO ₂ tank runs out for a period of time, the controller may take anywhere from a few hours to a couple of days to re-stabilize, this is normal. When the tank ran out, the PPM-2a tried to compensate by changing it's internal settings.
◆ My CO ₂ outlet never comes on.	◆ Make sure the CO ₂ disable function is not ON. ◆ If the actual CO ₂ level is above the set point (SV) the outlet will not turn on. Allow the level to drop, or raise the set point (SV).
◆ The fans are running so often, the CO ₂ is hardly ever ON.	◆ You may have too much heat building up in your area or too small of an exhaust fan. Reduce the heat sources or increase your fan size. ◆ You may also consider using a "closed-loop" air conditioner to keep the temperature and humidity below the set points so that CO ₂ is allowed to run for longer amounts of time.

PRECAUTIONS

- 1) ***Please take care in the handling of this precision device.*** If the unit is dropped or subjected to extreme shock, the calibration may be thrown off. Calibration problems due to abuse, or droppage may affect the warranty.
- 2) **DO NOT** expose the PPM-2a to water. It utilizes a ventilated enclosure to properly "sample" the CO₂.

WARRANTY

The PPM-2a is warranted against defects in workmanship for THREE years.

SPECIFICATIONS

Operating principle	Fuzzy Logic™, w / Single-beam Non-Dispersive Infrared (NDIR)
Measurement range	0 – 5000 PPM CO ₂
Warm-up time	Minimum 10 minutes (full accuracy)
Maximum drift per year	+/- 15 PPM
Accuracy @ 77°F	+/- 5% of reading
Repeatability	< 1% of Fixed Scale
Recommended calibration interval	Five years
Operating voltages	120vac
CO ₂ Disable function	120-volt AC, disables CO ₂
Operating temperature range	30-120° F
Operating humidity range	0-99% RH (non-condensing)
Operating life expectancy	15 years typical
Warranty	Three years, parts and labor through repair or exchange.

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