

Instruction Manual

GSM-4

4-Channel Programmable Gas Mixer



Read instructions carefully before operating this device.

- 1** This device is not to be used for Human Life Support applications.
- 2** To avoid possible electrical shock, do not operate this device if it is wet or has had liquids spilled onto it.
- 3** Service or calibration procedures should only be performed by qualified personnel familiar with the electrical hazards of line-powered devices.



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Instruments manufactured by CWE, Incorporated are not authorized for use as critical components in human life support devices or systems. "Life support devices or systems", as used herein, are devices or systems whose failure to perform, whether through misuse, failure, or proper operation, can reasonably be expected to result in significant injury to the operator or subject persons.

USER INFORMATION:

Base Unit Serial Number: _____

Gas: Channel A_____, Channel B_____, Channel C_____, Channel D_____

Flows: Channel A_____, Channel B_____, Channel C_____, Channel D_____

GSM-4-CommMX Software version: _____

Gas correction factors (see Note): enabled_____ not used_____

NOTE: If gas correction factors (K-Factors) are not used, this indicates the flow controllers for each channel are pre-calibrated with a specific gas for the highest accuracy. If **enabled** AND **not used** are checked, the flow controllers are calibrated using a specific gas, but the user has the ability to make small corrections using K-factor adjust.

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1.0 QUICK START GUIDE

This section provides a short guide to setting up and operating the GSM-4 Gas Mixer. A more detailed description will be found in later sections of this instruction manual.

- ❶ Equipment set-up:** Place the GSM-4 in a convenient location. If a computer is to be used for remotely controlling the GSM-4, it should be located nearby.
- ❷ Connect the tubing:** Connect the compressed gas sources to the gas inlets on the rear panel. Note that these are “one-touch” press-in tubing connectors. The gas outlet supplies the mixed gas.
- ❸ Connect the cables:** Connect the serial port cable between your computer and the GSM-4 rear panel connector. If your computer does not have a serial port, use the supplied USB-Serial adapter.
- ❹ Install the software:** Insert the GSM-4-CommMX USB flash-drive into your computer. Browse to `setup.exe` on the USB flash-drive. Follow the instructions to install the program.
- ❺ Start GSM-4-CommMX:** From the start menu, choose programs, and locate GSM-4-CommMX. Select it to run the program.
- ❻ Select config file:** A dialog box will open asking you to select a configuration file. Select `default.txt` to select a generic configuration file, or *cancel* to go directly to the main screen.
- ❼ Configure COM port:** Locate the COM PORT text box on the screen. This drop-down text box will show all available COM ports (serial ports) on your computer. Select the one you want to use. The program will not work if the correct COM port is not selected!
- ❽ Set flow ranges:** If not already displaying the channel flow ranges (bottom right of screen), enter them now.
- ❾ Power up the GSM-4:** Turn on the GSM-4 power. After an introductory message, the LCD will display the main screen. Select **LOCAL** if you want to begin making settings from the front panel, or **REMOTE** if you want to set up the GSM-4 from your computer.
- ❿ Ready to go!** Using either the front panel controls (**LOCAL** mode) or the GSM-4-CommMX software (**REMOTE**), select the gasses you have connected to the inlets. Adjust the percentages for each, and set the total flow desired.
- ⓫ Configurations:** The GSM-4 allows you to store up to four mixtures, which can be immediately accessed using the stored mixture knob. The GSM-4-CommMX software similarly allows setting up four mixtures. These sets of mixtures can be saved as configuration files. Use the configuration menu at the top of the screen to save or load these files.
- ⓬ Save on exit:** Use the **EXIT** pushbutton on the screen to close the program. A dialog box will open, asking you to save a configuration file. Select an existing file, or create a new one, or select *cancel* to exit without saving a configuration file.

① ③ Operating tips:

Give your configuration files meaningful names to allow easy retrieval and use in the future. A few sample files are included as examples.



2.0 INTRODUCTION

The GSM-4 Gas Mixer allows you to easily create accurate, custom gas blends using up to four different gasses. All parameters (gas type, percent of each gas in the output mixture, and total flow) can be set using the front panel controls, but can most conveniently be set using the provided **GSM-4-CommMX** software. Most GSM-4 configurations use Mass Flow Controllers calibrated for a specific gas (see User Information on page 2).

A typical application of the GSM-4 is to generate gas mixes for hypoxia, hypercapnia, or other respiratory gas studies. Because these studies often involve a low concentration of one gas relative to the other gas components, one GSM-4 flow channel normally uses a different range flow controller. A typical configuration might be as follows (your instrument may be different):

Note: Each GSM-4 is customized to the user's requirements with the appropriate mass flow controllers installed (see page 2 for your configuration). Examples shown in this manual will probably differ from yours.

Channel:	Gas	Nominal Range	Usable Range
GAS 1	N ₂	0 – 10,000 ml/min	100 – 10,000 ml/min
GAS 2	O ₂	0 – 5,000 ml/min	50 – 10,000 ml/min
GAS 3	CO ₂	0 – 1000 ml/min	10 – 1000 ml/min
GAS 4	He	0 – 1000 ml/min	10 – 1000 ml/min

For the best accuracy, any of the channels should only be set within the usable range for that channel.

The **GSM-4-CommMX** software provided allows the user to save any number of pre-set configurations for later use. These mixtures can then be downloaded and run on the GSM-4 itself.



Figure 1: GSM-4 Gas Mixer front panel

3.0 SETUP

Setting up the GSM-4 Gas Mixer is straightforward. The following instructions assume that a computer with a standard serial port is available, or a USB-Serial adapter cable is used.

1. Install the GSM-4 Gas Mixer in a location convenient to the gas sources, and near the computer that will be used with it. The unit can be rack mounted if desired.
2. Connect your pressurized gasses to the **GAS 1**, **GAS 2**, **GAS 3**, and **GAS 4** ports on the rear panel. These ports require 0.25" (6.35mm) O.D. semi-flexible tubing, which makes a press-fit connection. To disconnect any of the tubing connections, press in on the outer ring of the connector and pull out the tubing. Gas pressures should be in the range of 20 - 50 psi (1.4 – 3.4 bar).

Note: Most GSM-4's will be configured for specific gasses, which must be connected to the appropriate inlet.

3. Connect the **GAS OUTLET** port using the same type tubing or use one of the hose-barb adapters included with the system.
4. Connect the supplied serial port cable from your computer to the 9-pin female RS232 port on the rear of the GSM-4. If your computer does not have a serial port, install and use the supplied USB-Serial adapter. This adapter will create a virtual COM port, whose COM number can be located at: Control Panel / System / Device Manager / Ports (COM & LPT) / USB-Serial COM4 (typical, but your COM port number may be different).
5. Install the **GSM-4-CommMX** software on your PC. Insert the flash-drive in your computer and run `Setup.exe`. We recommend accepting the default file locations.
6. When the GSM-4 is turned on, select **LOCAL** to set up the instrument from the front panel, or **REMOTE** to use the GSM-4-CommMX software. Be sure to set the COM port to the actual port used on your computer.

4.0 OPERATION

The instructions below describe the procedure for setting up gas mixtures and running them from the instrument itself. The operation of the **GSM-4-CommMX** software is described later.

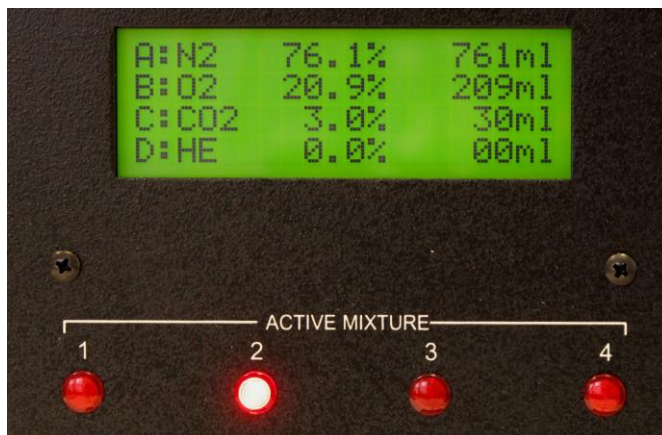


Figure 2: GSM-4 LCD panel

4.1 CREATING A GAS MIXTURE (LOCAL MODE)

Be sure the **LOCAL / REMOTE** switch is set to **LOCAL**.

Up to four custom gas mixtures can be created and stored in the GSM-4. To create, edit, or run any of these, use the **STORED MIXTURE** knob. When any of the stored mixtures is selected, its current settings will be displayed on the LCD panel.

Selecting gasses – Using the **GAS SELECT** knob, select either A, B, C, or D. While holding the **SELECT GAS / SET %** lever switch in the **SELECT GAS** position, rotate the **ADJUST** knob until the desired gas is shown on the display. Perform this procedure to set gasses A, B, C, and D.

Note: Most GSM-4's will be configured for specific gasses for each of the four channels.

Setting gas percentages – Each gas can be set to anywhere in the 0 – 100% range, with 0.1% resolution. The total should add up to 100%, or the flows will be inaccurate. The **ERROR** light will turn on and stay on until the gas fractions add up to 100 percent. To set a percentage, first point to A, B, C, or D using the **GAS SELECT** knob. While holding the **SELECT GAS / SET %** switch in the **SET %** position, rotate the **ADJUST** knob until the desired percentage is shown on the display. Repeat for the other gasses. Remember that the total should add up to 100%!

Setting flow – The GSM-4 allows you to set the **total flow** of the mixture only. Individual gas flows are computed based on the selected percentage, and shown on the display, but the user cannot change these directly.

To set the total flow, rotate the **SELECT GAS** knob to the **TOTAL FLOW** position. Use the **ADJUST** knob to set the flow, which will be displayed on the LCD panel.

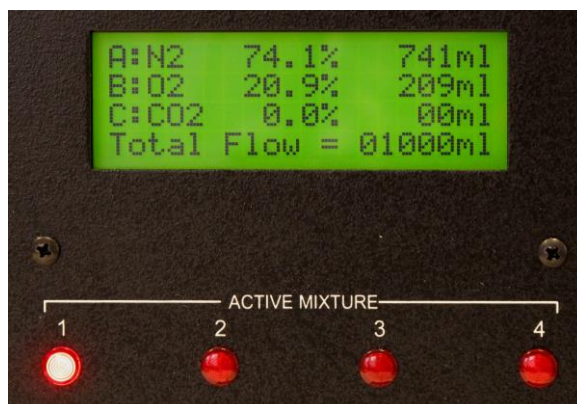


Figure 3: GSM-4 LCD panel showing Total Flow

Storing the mixture -- After a mixture is configured, press the **EXECUTE** pushbutton, which will store the mixture and start it running. Press the **SHUT OFF FLOW** pushbutton to stop the flow. The mixture is now stored in non-volatile memory, and will be available even if the instrument has been turned off, and then on again.

The four stored mixtures can be created and stored as described above, and can be selected and executed any time the instrument is used.

4.2 NOTES ON GAS MIXTURES

No flowmeter or flow controller is “ideal”; i.e., it does not operate linearly over a zero – full scale range. The range of operation is known as the *turndown ratio*. This is simply the ratio of full-scale to minimum usable range. In the case of the GSM-4 controllers, this turndown ratio is approximately 100:1. For example, a 1000sccm (standard cc/minute) controller can accurately operate over a 10 – 1000sccm range.

The practical result of this information is that all possible combinations of mixtures and flows may not be accurate if any of the gas channels fall outside of the usable range for that channel. If any of the computed flows falls below the minimum usable flow, the **TOTAL FLOW** should be increased to raise the channel flow above the usable lower limit. The following example illustrates this condition:

Desired flow mixture, total flow = 500 ml/min, initial settings:

Channel	Flow Range	Min usable flow	Percent of mix	Computed channel flow
GAS 1 (N₂)	5000 sccm	50 sccm	73.0%	365 sccm (good!)
GAS 2 (O₂)	2000 sccm	20 sccm	21.0%	105 sccm (good)
GAS 3 (CO₂)	500 sccm	5 sccm	0.5%	2.5 sccm (bad!)
GAS 4 (He)	4000 sccm	40 sccm	5.0%	25 sccm (bad!)

NOTE: Flows shown as sccm (Standard cc/min)

The flows for **GAS 3** and **GAS 4** fall below the usable minimums. To correct this, increase the **total flow** to move these individual flows into the usable ranges.

4.3 INDICATOR LIGHTS

The various indicator lights give important information about the operation of the GSM-4 Gas Mixer.

Active Mixture lights – These four red LED's indicate which mixture is currently selected by remaining steadily on. A blinking **ACTIVE MIXTURE** led indicates that a particular mixture is currently running (flow is being delivered). Even while one mixture is running, the **STORED MIXTURE** knob can be used to select another mixture for configuration. In this case, one of the LEDs will be blinking (that mixture is running), and another is steadily on (indicating that that mixture is being displayed for editing, etc.).

Running light – This green LED will turn on when gas is actually flowing; i.e., a mixture is currently running.

Error light – This red LED will indicate setup errors, such as when the gas percentages do not add up to 100%.

4.4 IMMEDIATE ACTION CONTROLS

As described above, the **EXECUTE** pushbutton will immediately cause the currently selected mixture to run. Conversely, pressing the **SHUT OFF FLOW** pushbutton will immediately shut off the flow controllers.

4.5 LOCAL / REMOTE SWITCH

Set this switch to **LOCAL** to perform gas mixture setup and execution from the GSM-4 front panel. Set this switch to **REMOTE** to use the **GSM-4-CommMX** software to remotely control the instrument. Note that in remote mode, the **ACTIVE MIXTURE** led's are not automatically on, indicating that the **STORED MIXTURE** switch setting is ignored, since this function is performed by the software.

5.0 REAR PANEL CONNECTIONS

Gas Inlets – These ports are used to connect any of the four inlet gasses. The connectors are compatible with ¼" OD semi-flexible pneumatic tubing (urethane or similar). Press in the outer ring of the connector to withdraw the tubing.

Gas Outlet – This port provides the gas mixture created by the GSM-4.

Note: Your GSM-4 may have one or more additional Outlets. This allows one or more gas channels to be used independently.

Fuse – In case this fuse blows, replace it with one of the same current and voltage rating as the original. If the fuse blows repeatedly, the instrument should be returned for service.

Serial Port – The RS232 serial port uses a standard 9-pin D-sub connection. This port should be connected to your computer using a straight-wired cable (not a crossover or modem cable). Use the supplied USB-Serial adapter if a true serial port is not available.

Analog Outputs – These BNC jacks provide an analog voltage corresponding to the flow rate of each of the four gasses in the current gas mixture. The range of this signal is 0 – 5V, where 5V is the full-scale range of the particular flow channel.

6.0 USING CORRECTION FACTORS

Different gasses have different physical properties (density, viscosity, etc.) and thus behave differently with Mass Flow Meters and Controllers (MFCs). Most GSM-4 systems are shipped with MFC's pre-calibrated for specific gasses, which gives the best accuracy.

When more than one gas is to be used on a gas flow channel, that MFC is typically calibrated for nitrogen, and a *correction factor* (also called K-factor) is applied to match the new gas. If K-factors are enabled on your GSM-4 system (see page 2, *User Information*), these corrections will be applied when you select a gas, either from the front panel or using the **GSM-4-CommMX** software.

Note: Most GSM-4's will be configured for specific gasses, which must be connected to the appropriate Gas Inlet. These mass flow controllers are factory calibrated using the actual gasses, and DO NOT use correction factors.

Some systems using specific, pre-calibrated gasses also allow user-adjustable flow corrections. See: User Information

ADJUSTING CORRECTION FACTORS

Although flows generated using K-factors are generally accurate to within $\pm 4\%$, you can adjust them to provide the best accuracy under the specific laboratory conditions of the user. The procedure described below explains how to do this.

1. Set up and run a gas mixture using the gas you want to calibrate. For example, 5.0% CO₂, 95% nitrogen.
2. Switch to **LOCAL CONTROL**.
3. Monitor the actual output concentration of the target gas (CO₂).
4. Press the **ADJUST KNOB** to display the “**Adjust K-factor**” menu:

Set gas K-factor
Select gas: AIR
SHUT OFF to exit
KNOB to accept

5. Rotate the **ADJUST KNOB** until the desired gas is displayed:

Set gas K-factor
Select gas: CO₂
SHUT OFF to exit
KNOB to accept

6. When the target gas is shown, press the **ADJUST KNOB**. The following screen will appear, showing the current K-factor for that gas:

Set gas K-factor
CO₂ K = 167
SHUT OFF to exit
KNOB to accept

7. Rotate the adjust knob to increase or decrease the displayed K-factor. *Increasing* it will cause a higher flow of that gas at the outlet, and *decreasing* it will result in a lower flow. In the example above, if a 5.0% CO₂ mixture is set up, but the actual measured concentration reads 4.6%, try increasing the K-factor by 13 (about 8%) to 180. After making this change, press the **ADJUST KNOB** to accept and store this change. The GSM-4 will re-start, and apply the new K-factor.
8. After re-starting, the previously run test gas mixture should be displayed. Run it, and note the output gas concentration. If the concentration still needs adjustment, repeat the above procedure activated by pressing the **ADJUST KNOB**. After this procedure is completed, the K-factor is stored and will be applied automatically whenever the GSM-4 is used.

Note: Even with pre-set gasses, you can use this same procedure (if K-factors are enabled) to make small changes on any gas channel. Stored values will be 100, and the user can increase or decrease the scale factor within the range 10 – 255.

7.0 FLOW ALARMS

The GSM-4 Gas Mixer is equipped with an alarm system to detect a discrepancy between the *requested flow* and the *actual output flow* from any of the four Mass Flow Controllers (MFC's). The major trigger conditions for this alarm are:

1. There is zero output flow from any MFC.

MOST LIKELY CAUSE: *A gas supply tank is empty, supply valve is shut off, etc.*

2. The output flow is substantially different (higher or lower) than the requested flow.

MOST LIKELY CAUSE: *Low or varying gas supply pressure, or (rarely!) a failed MFC.*

When an ALARM is triggered, the 4th line of the LCD will show which gas channel is at fault. This message will be dismissed after ten seconds and return the display to normal. You can clear the message immediately by pressing the **ADJUST KNOB**.



A: N2 0.0% 000m
B: O2 0.0% 000m
C: CO2 0.0% 000m
<CHECK GAS SOURCE 4>

Line 4 shows **Alarm source**, but will return to displaying Gas D when alarm is cleared.

Figure 4: GSM-4 Alarm display

ENABLING OR DISABLING FLOW ALARMS

Although we recommend using the built-in alarms, they can be turned off if desired. One possible reason might be that a very rapid gas switching routine is used (see: *Sequencer*). If the gasses are cycled faster than once every three seconds, a false alarm could be issued.

To Disable or Enable Alarms – Simultaneously push and hold the **ADJUST KNOB** and the **SHUTOFF FLOW** pushbutton while switching **POWER** on. Hold for about a second and then release. This procedure toggles the alarms on or off. When enabled (or re-enabled), you will hear three beeps. When disabled, a single beep will sound.

8.0 SPECIFICATIONS

Flow controller type.....	thermal mass flow controllers
Linearity (0 - 100%)	±1%
Repeatability and hysteresis	±0.15%
Long-term stability	±0.2% full scale / 7500 hours continuous operation
Response time	<1 second, typical
Operating temperature.....	0 - 50°C
Operating pressure range (25psi calibration pressure)	0 – 50psi
Usable flow range (Note1)	0.01 – 1.0 x controller range
Analog outputs (for Gas 1, 2, 3, and 4).....	5.0V for channel full scale flow
Analog output connectors (rear panel).....	BNC jacks
Serial communication format	19,200 baud, 8 data bits, no parity, 1 stop bit
Serial output connector (rear panel)	DB9 female
Gas inlet and outlet connections	¼” One-Touch press-in connectors
Dimensions	19W x 5.25H x 12D in.
Power requirements.....	115/230V, 50/60Hz (universal), 50VA

Note1: Actual flow depends on flow controllers installed in your system.

9.0 GAS CHARACTERISTICS

If your GSM-4 Gas Mixer has one or more channels calibrated for nitrogen, you can apply a K-factor to make it work with one of the gasses listed below. Note that these almost always reduce the accuracy as compared to a channel calibrated for a specific gas. These K-factors correct for the densities of gasses relative to nitrogen. In case your gas is not one of those programmed into the instrument, you can choose among the pre-programmed gasses one that has similar characteristics to your gas. This way, the mixture will remain accurate.

Gas No.	Programmed gas	Symbol	Stored K-factor	K-Factor
1	Air	AIR	100	1.00
2	Nitrogen	N ₂	100	1.00
3	Oxygen	O ₂	101	0.99
4	Carbon dioxide	CO ₂	167	0.74
5	Helium	He	70	1.42
6	Argon	Ar	70	1.42
7	Carbon monoxide	CO	100	1.00
8	Neon	Ne	70	1.42
9	Nitric oxide	NO	100	1.00
10	Nitrous oxide	N ₂ O	141	0.71
11	Sulfur hexafluoride	SF ₆	255	0.26
12	Xenon	Xe	70	1.42
13	Methane	CH ₄	139	0.72

Note: The **Stored K-factor** is the correction multiplier used by the internal GSM-4 software.

Other gasses	Symbol	K-Factor
Ammonia	NH ₃	0.74
Butane	C ₄ H ₁₀	0.26
Freon-14	CF ₄	0.42
Chlorine	Cl ₂	0.86
Chloroform	CHCl ₃	0.39
Ethane	C ₂ H ₆	0.50
Ethylene	C ₂ H ₄	0.60
Ethylene oxide	C ₂ H ₄ O	0.52
Krypton	Kr	1.41

10.0 GSM-4-CommMX SOFTWARE

The software provided with the GSM-4 system is used to remotely control the Gas Mixer. All the functions available on the front panel of the GSM-4 can be performed using this software. Multiple configuration files can be easily created and saved to disk on the computer for later use, and automated timed switching, or sequencing of gas mixtures can be performed.

In addition to the standard 4-channel gas mixing function, there are two additional user-selectable MODES of operation that will be described here:

MODE 1: 4-channel GSM-4 Gas Mixer: (4 gasses, 1 selected as FILL GAS)

MODE 2: Independent: Each channel independently adjustable, no auto Fill Gas calculations.

MODE 3: Mimic mode: Channels 1 – 3 act as a 3-channel gas mixer, Channel 4 flow is always equal to the Total mixture flow from Channels 1 – 3.

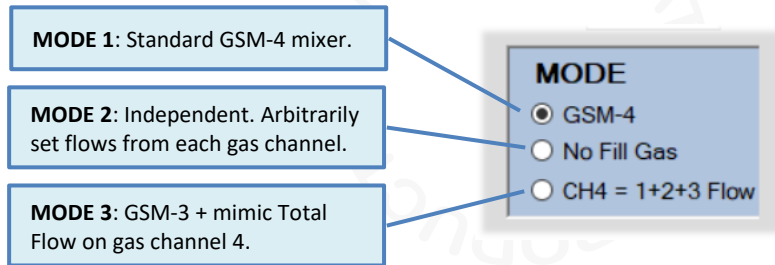


Figure 5: GSM-4-CommMX Mode selection)

The following screenshots show these three operational modes. The setup instructions are common to all modes, except as indicated. These instructions assume that the **GSM-4-CommMX** software has been successfully installed.

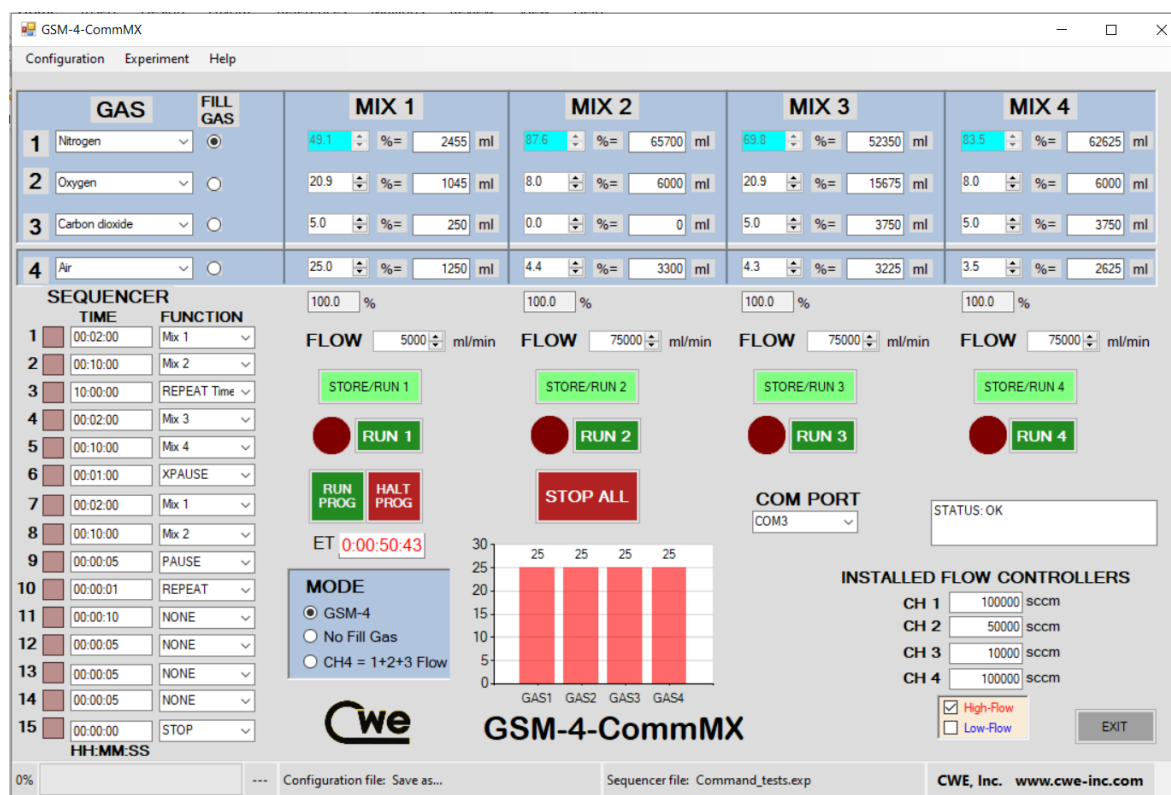


Figure 6: GSM-4-CommMX screen (MODE 1: Four-channel mixer mode shown)

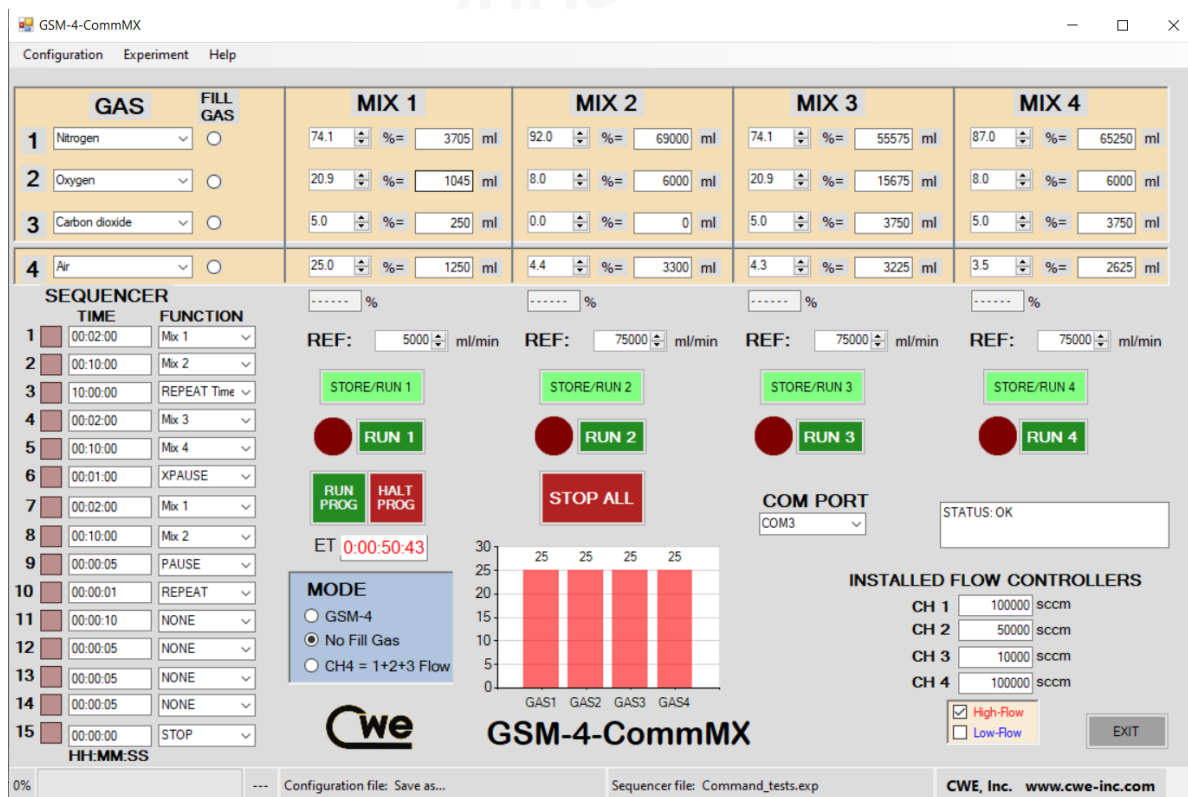


Figure 7: Independent (MODE 2: all channel flows independently set)

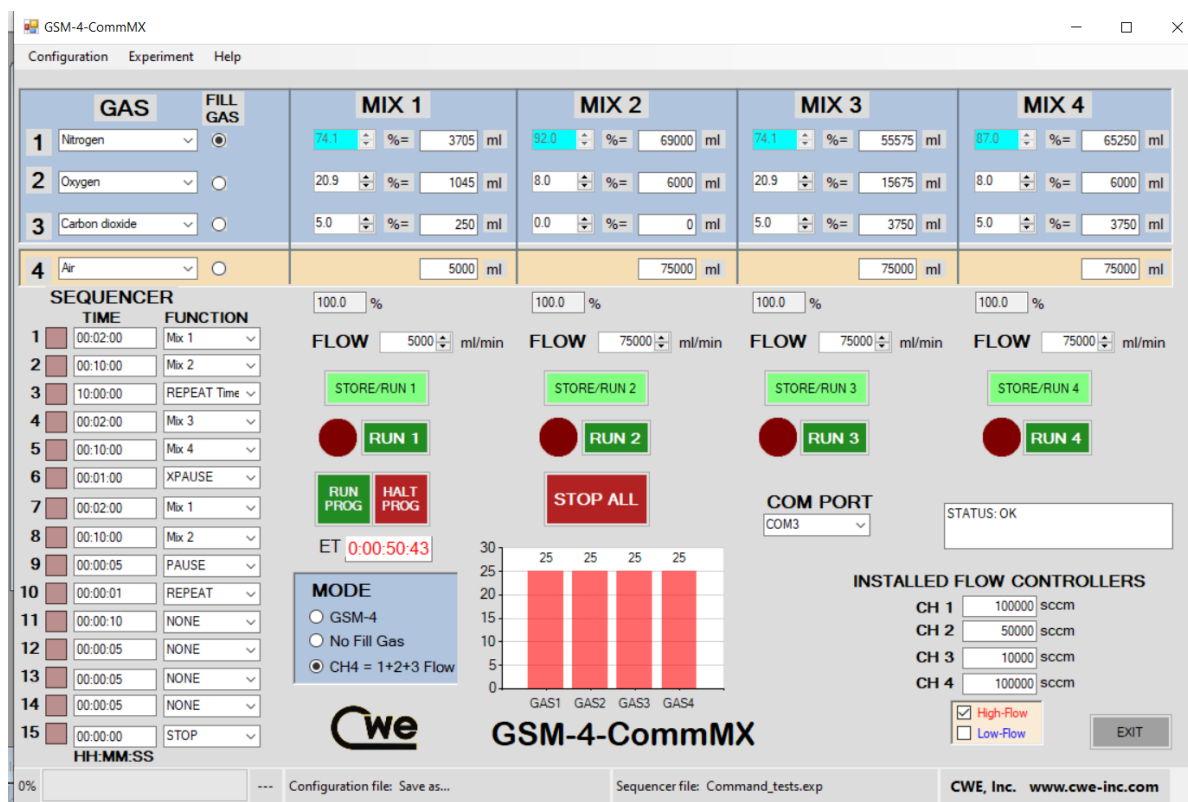


Figure 8: Mimic (MODE 3: Channel 4 = Total Flow of mixture)

Setting the COM port – Use the **COM PORT** control on the screen to select the COM number of the serial port on your computer. The control will automatically be populated with the available serial ports on your computer. If you are using a USB-Serial Port adapter, you can find the assigned COM port number by looking at: Start / Control Panel / System / Hardware / Device Manager / Ports.

Set flow ranges – Enter the flow ranges of the installed flow controllers in your instrument in the four labeled text boxes near the bottom right of the main screen (shown below). These values are saved with any mixture configuration setting files (see below), and are automatically re-entered whenever a configuration file is loaded.

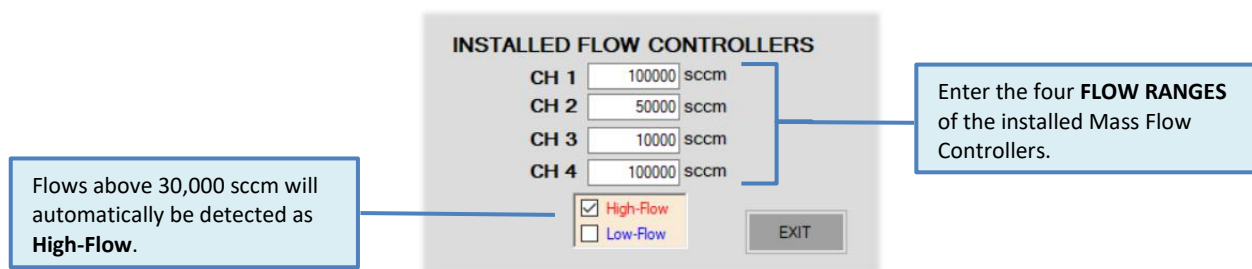


Figure 9: Mass Flow Controller values entered for each channel.

Load and Save Configuration -- These operate as you might expect: `Load configuration` will retrieve from disk a set of previously stored settings; `Save configuration` will save the current settings to a file of your choice. You might try loading one of the pre-configured files to see how this works (e.g., the `hypoxia` file). The name and path of the file in use will be displayed in the status bar at the bottom of the screen.

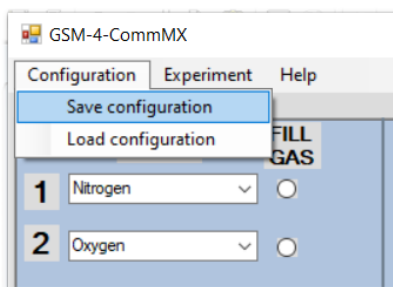


Figure 10: Drop-down Configuration menu.

Selecting gasses – On the left side of the screen, you can select any of the programmed gasses using the drop-down menus. These should correspond to the actual gasses connected to the **GAS 1**, **GAS 2**, **GAS 3** and **GAS 4** inlets.

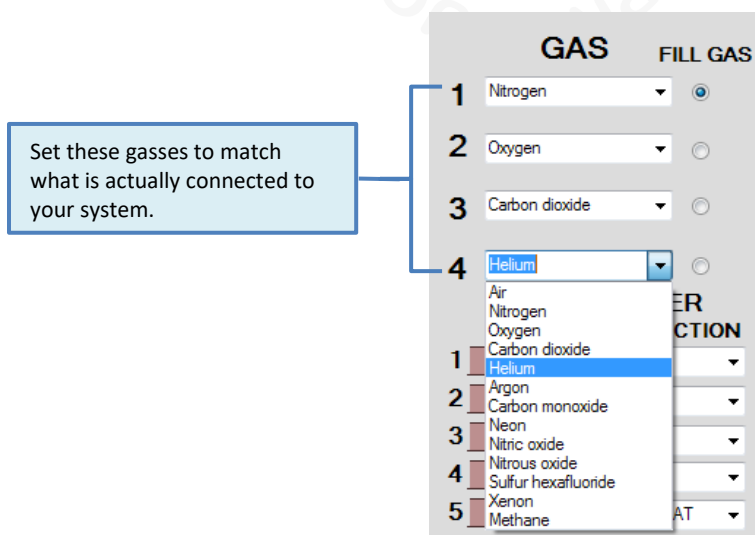


Figure 11: Gas selection drop-down menu

Fill Gas – For the individual channel concentration settings to make sense, they must add up to 100 percent. In most cases, three of the four gasses are of primary interest (referred to here as “active” gasses), and the fourth gas (often nitrogen) makes up the balance of the mixture. Use the **FILL GAS** buttons to select the gas that will make up this balance. This gas concentration will automatically be adjusted when the other three gas percentages are changed.

Mixture settings – Enter the desired gas percentages in the appropriate boxes by using the spin controls next to each box. If any computed flow is outside the range of the channel flow controller, it will be shown in red, and a warning message will appear in the status box at the bottom of the screen. If any flow is shown to be too low, it is often possible to bring it back into a usable range by increasing the **TOTAL FLOW** (see below).

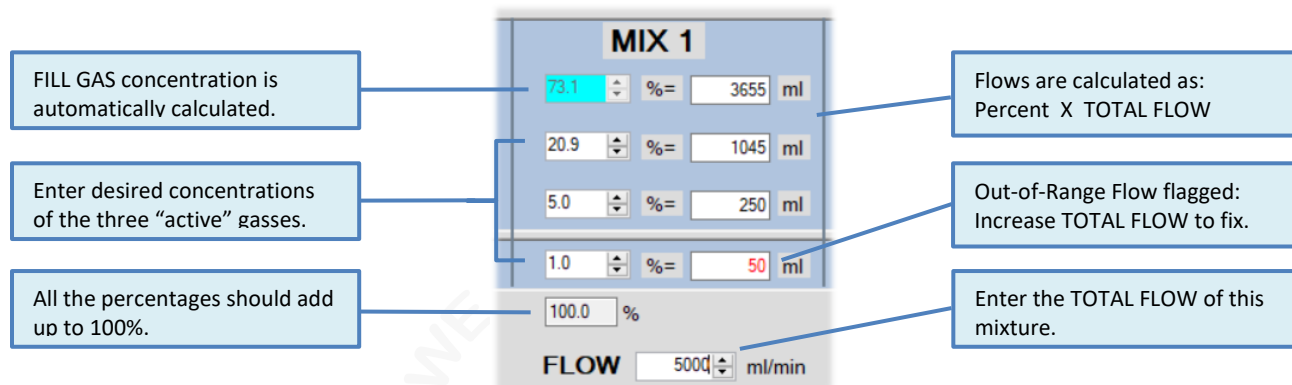


Figure 12: Mixture configuration panel, GSM-4 mode.

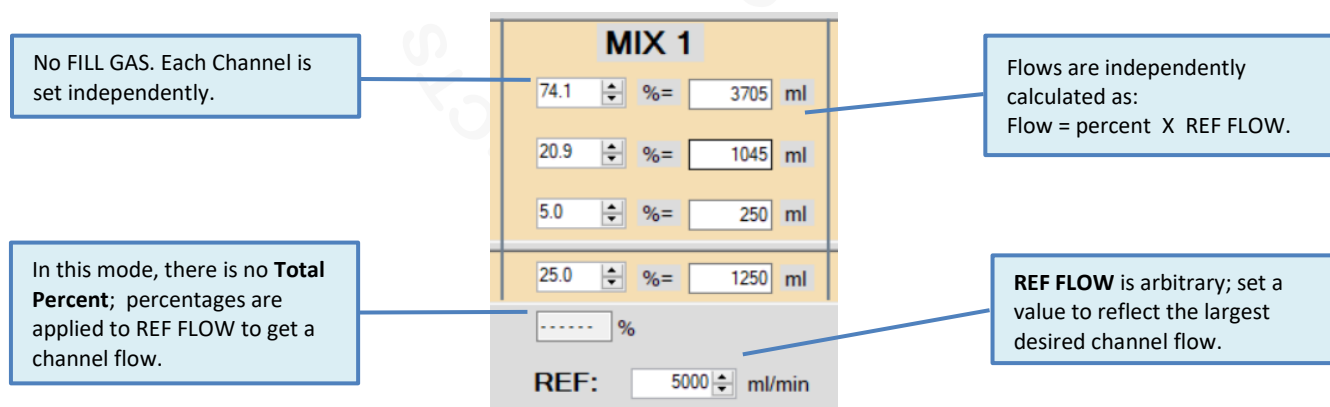


Figure 13: Mixture configuration panel, Independent mode.

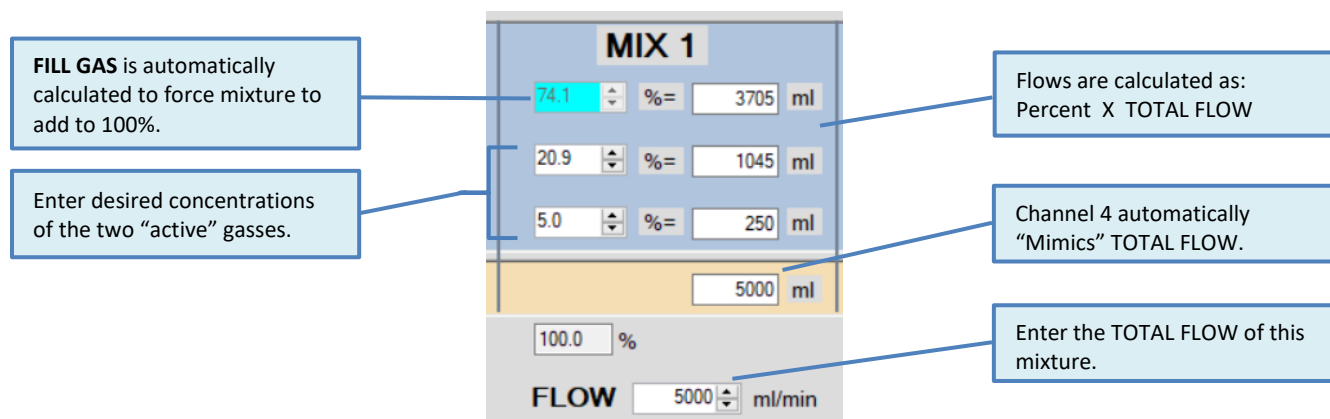


Figure 14: Mixture configuration panel, Mimic mode.

Total Flow – Enter the total mixture flows in the **FLOW** boxes (labeled with "ml"). The total flow will be limited to that available from the installed flow controllers.

Store - Run button – Clicking any of these light-green buttons causes the selected mixture to be downloaded to the GSM-4 and immediately executed. It will be stored in the GSM-4 for later use. Each mixture must be separately downloaded.

Run button – These dark-green buttons cause the GSM-4 to immediately execute the corresponding stored program. A blinking red indicator next to the button will show which mixture is running. Note that these **RUN** buttons execute the program currently stored on the GSM-4 in the corresponding location (Mix 1 – 4). Therefore, if the GSM-4 has been previously configured with stored programs, these will be run (which may be different from those shown on the software screen).

Stop All button – Click this button to turn off all the flows immediately.

OPERATING THE SEQUENCER

The **SEQUENCER** panel allows a timed sequence of gas mixtures to be delivered, and either repeated indefinitely, or terminated after one sequence has completed. This section explains how to set this up. This important feature of the **GSM-4-CommMX** software allows fully automated operation of the GSM-4 Gas Mixer.

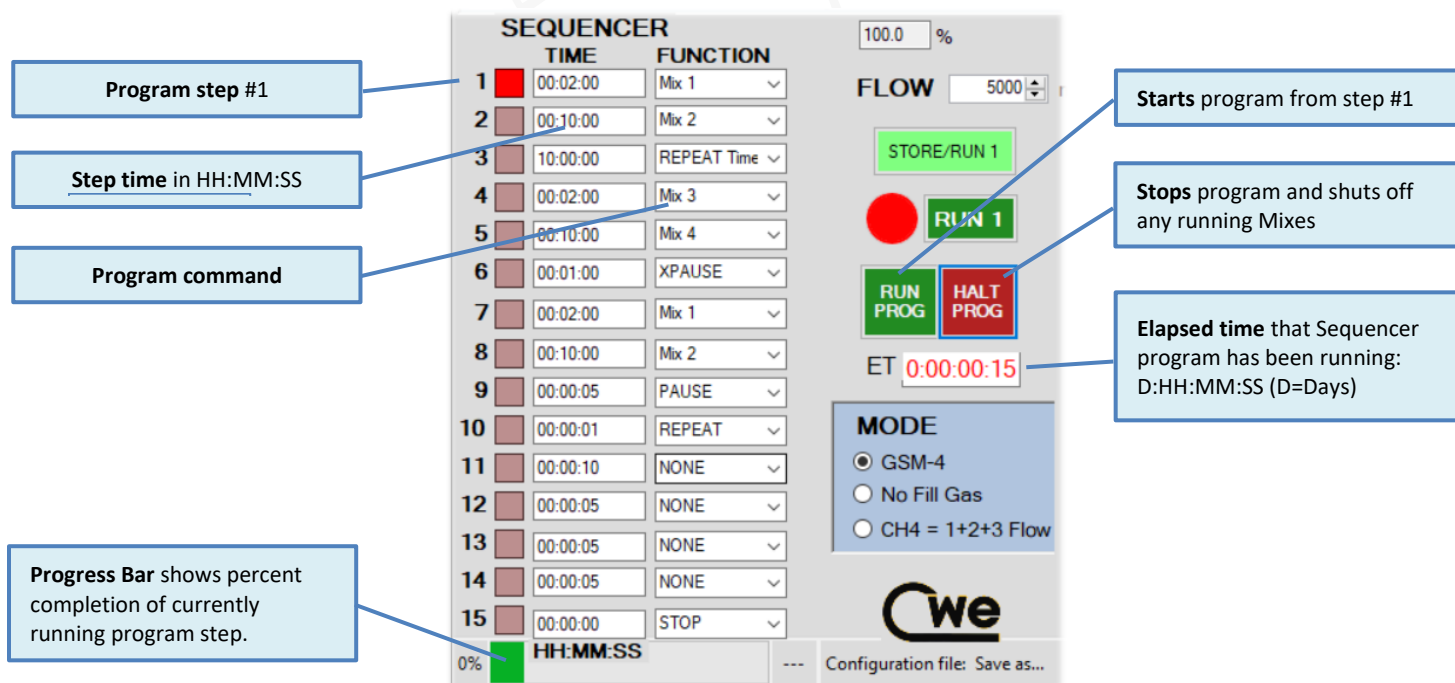


Figure 15: Timed experiment setup using the Sequencer

The **SEQUENCER** panel allows a timed sequence of gas mixtures to be delivered, and either repeated indefinitely, or terminated after one sequence has completed. The setup is straightforward: In the right-hand box, use the drop-down menu to select a **FUNCTION** for that step in the sequence. This can be either **Mix 1**, **Mix 2**, **Mix 3**, **Mix 4**, **REPEAT**, **REPEAT Time**, **PAUSE**, **XPAUSE**, **GOTO**, **STOP**, or **NONE**. In the

left-hand box, enter the desired duration of that step in **HH:MM:SS** (Hours, Minutes, Seconds) format.

These functions are somewhat self-explanatory;

Mix 1 - 4 runs the specified mixture for the programmed time.

REPEAT starts the sequence steps above this command again from the top.

REPEAT Time repeats commands above it for a specified time. When that time has elapsed, execution goes to the following command.

PAUSE waits for the programmed time, without changing or stopping any running mixtures.

XPAUSE immediately shuts off any running Mixture, waits for the programmed time, and then continues to the next program step.

GOTO causes execution to jump to the command line number programmed into the seconds (SS) section of the time panel.

STOP turns off all flows and halts the sequencer.

Note that you must set up each of the four mixtures in advance, although you can change any mix parameter (and sequencer times) while the sequencer is running.

Exit button – Click this to exit the program. A dialog box will open asking you to save the configuration file. Select an existing file, create a new file, or simply select *cancel* to skip this and exit immediately.

11.0 Appendix A: GSM-4 Communication protocols

The GSM-4-CommMXsoftware communicates with the GSM-4 Gas Mixer hardware via the serial protocol described below. This description is provided in case the user wants to develop his own custom control software using, for example, Labview or Visual Basic.

In addition, the file format of the configuration files used by the GSM-4-CommMXprogram is described. These text files can be easily created using Notepad or any text editor.

Direct communication with GSM-4 Gas Mixer:

Serial protocol 19,200,N,8,1

One-byte commands (immediate execution) are sent as simple ASCII text:

“1” = execute stored program 1

“2” = execute stored program 2

“3” = execute stored program 3

“4” = execute stored program 4

“9” = halt any running program

Normal program string (15 bytes):

These are actual values (not ASCII text), and usually sent as chr(x) or chr\$(x) by the control software. For example, if you want to send the value 12, you would send chr\$(12), and NOT “12” as text. No termination characters should be sent; just send the 15 bytes as shown below. The example program in the table below would set up the GSM-4 to do:

Mix #1, gas1 = oxygen, %gas1 = 20.9, gas2 = carbon dioxide, %gas2 = 0.1, gas3 = nitrogen, %gas3 = 79.0, total mix flow = 1000 ml/min

Byte	Description and range	Example	Meaning
1	Mix number (1 – 4)	chr\$(1)	Mix = 1
2	gas1 (1 - 13)	chr\$(3)	oxygen
3	pct1.highbyte (0 – 255)	chr\$(0)	20.9%
4	pct1.lowbyte (0 – 255)	chr\$(209)	
5	gas2 (1 - 13)	chr\$(4)	carbon dioxide
6	pct2.highbyte (0 – 255)	chr\$(0)	0.0%
7	pct2.lowbyte (0 – 255)	chr\$(1)	
8	gas3 (1 - 13)	chr\$(2)	nitrogen
9	pct3.highbyte (0 – 255)	chr\$(2)	74.1%
10	pct3.lowbyte (0 – 255)	chr\$(229)	
11	Gas4 (1 - 13)	chr\$(5)	Helium
12	Pct4.highbyte (0 – 255)	chr\$(0)	5.0%
13	Pct4.lowbyte (0 – 255)	chr\$(50)	
14	totalflow.highbyte (0 – 255)	chr\$(3)	1000 ml/min
15	totalflow.lowbyte (0 – 255)	chr\$(232)	

Notes: Gas identification number is the same as in the table in Section 7.0. For example, oxygen = 3.

Configuration file format:

This is the file format used by the **GSM-4-CommMX** program to save and load configuration data. Note that this is a simple text (ASCII) string of numbers, with comma delimiting.

Example:

```
2,3,1,209,1,790,1000,150,1,849,1000,120,1,879,1000,100,1,899,1000<cr>
```

This is interpreted as follows:

```
gas1, gas2, gas3, gas4, %gas1, %gas2, %gas3, %gas4, total flow, %gas1, %gas2,
%gas3, %gas4, total flow, %gas1, %gas2, %gas3, %gas4, total flow, %gas1,
%gas2, %gas3, %gas4, total flow, <ret>
```

(red = mix1 values, green = mix2 values, blue = mix3 values, orange = mix4 values)