ATOM FGA-1000

Flare Gas Analyzer for Total Sulfur
User's Manual

(Revision D)

Table of Contents

Introduction

Letter from the President

Dear Valued Customer,

During the past several years, we have experienced extraordinary growth and change at ATOM Instrument, due to our continued commitment to teamwork, technology-focused product strategies and to our policy of placing the trust of our customers above all else. We have successfully reached key milestones, expanded research and development initiatives, achieved significant technological advancements and initiated our position as a premier manufacturer and developer of analytical instrumentation. In the face of challenging economic conditions, we are finding new ways to provide solutions to an evolving industry landscape to ensure ATOM remains the brightest light on the marketplace.

The upcoming years will be exciting as we continue to broaden our business efforts and move from promise to product. We have set increasingly ambitious goals, but possess the passionate vision and resources to achieve them. We have the knowledge, experience and expertise to bring specialty products to this niche market, and we know the steps we need to take are simply an extension of what we have been doing successfully since our inception. Simultaneously, we plan to continue responding to market challenges and expand our line of analyzers with products incorporating enhanced features in order to engage a wider customer base. Consequently, we have set an aggressive timeline for the development of new products to fulfill our commitment to a "total sulfur and nitrogen analysis solution."

One of our customers has described our success story as "more a marathon than a sprint." We take pride in this characterization and embrace it as the philosophy for our operations as a successful business is built on sustainable and reliable growth. In recent years, we've grown our business substantially, yet managed to never waver from our promise to deliver the very best products and service to our valued customers. ATOM is building the analyzer tools of tomorrow, hearing the markets' demands and we are ready to meet the challenges. Watch us closely; the next five years will be a defining notch in ATOM's timeline.

I credit each of our devoted employees for making these past years such a success in turbulent times. I would also like to extend my thanks to our customers and our suppliers for their unfailing sense of devotion, responsibility, guidance and support, without which our Excimer light would have surely extinguished long ago.

Thank you for the purchase of this ATOM Instrument product and please trust in our commitment to your complete satisfaction. Should you have any concerns, please do not hesitate contacting us for support.

Sincerely,

Franek Olstowski, President/Founder

Mission Statement

ATOM Instrument is founded on fundamental principles and timeless values that perpetually lie at the heart of our business and represent the structural foundation on which it is built. These principles have helped ATOM Instrument set a higher standard for its products and services, making it a recognized leader for innovative solutions. Our mission is to become a market leader in the development and manufacturing of analytical instrumentation with unsurpassed performance that will fulfill a strategic role in industry to control processes, verify product conformance and help solve a variety of problems for the benefit of society.

Creativity

– To establish and maintain an environment that encourages creativity and promotes innovation in order to capitalize on collective talents and intellectual resources, to maintain a technologically advanced position and competitive edge within the market.

Quality

– To provide superior quality products in both form and function while continually striving to improve what may already be the best in its class.

Integrity

– Above all, to conduct all aspects of business operations while adhering to the highest level of business ethics and standards.

Dependability

– To proactively address and reliably respond to our customer's needs in a timely fashion.

About This Manual

This manual is a multipart user's manual that provides information regarding the proper installation, operation and service of ATOM Instrument's FGA-1000 Sulfur Process Analyzer. The manual is divided into the following six sections.

- **Section 1**   Principle of Operation, Specifications, and Drawings

- **Section 2**   Software Operation

- **Section 3**   Basic Maintenance Guide

- **Section 4**   FGA-1000 MODBUS Digital Communications

- **Section 5**   ATOM2 Scanner Operation and features

- **Section 6**   Postscript

Warranty, compliance, and safety information concerning the FGA-1000 Sulfur Process Analyzer is provided immediately following this page.

The benefits, features and configurations of the FGA-1000 are described in Section 1 along with basic theory and operations.

Installation and operation of the FGA-1000 and most optional equipment are illustrated in Sections 2 and 3 of this manual. Future Information may be supplied in other manuals (i.e., options manuals) or addenda to this manual.

Maintenance information includes step-by-step procedures along with a complete set of drawings and schematics.

The information contained herein is furnished without warranty of any kind. Users should consider the data in this manual only as a supplement to other information gathered by them and must make independent determinations of the suitability and completeness of the information.

Some of the terms and labels used in the manual are abbreviated intuitively due to space constraints in tables, photos and illustrations. For further explanation, contact ATOM Instrument service.

Conditions for Proper Use

The FGA-1000 analyzer is designed to be installed, operated and maintained as specified in this manual. Failure to operate the analyzer as specified may produce erroneous data and possible equipment failure which may void the warranty. Some of the conditions for proper and improper use of the FGA-1000 analyzer are provided as follows:

- The FGA-1000 analyzer is designed to continuously analyze gaseous samples from a sample handling system and display the amount of sulfur contained in the sample. Operation for any use other than specified may damage the analyzer and/or cause personal injury to the operator. The results obtained from any other use cannot be guaranteed.

- The standard configuration of the FGA-1000 analyzer is not intended for extended use in corrosive environments.

- The FGA-1000 analyzer can be operated in open, outdoor environments but should not be exposed to direct sunlight or precipitation.

- The best accuracy and precision is obtained when the analyzer is located in a temperature controlled environment.

- To ensure safe operation, the purge system should always be engaged during operation of the analyzer except after the area has been determined to be non-hazardous and repairs or tests must be performed that require the purge system to be bypassed. Refer to the manufacturer documentation included in the appendix sections of this manual regarding the purge system operation.

- The electrical power source for the analyzer must be capable of delivering greater than 3000 Watts of power from a 120-VAC source.

- The sample to the analyzer must be filtered through a 2-micron (min) filter and delivered to the analyzer by an approved, leak-free sample handling system to ensure the sample being analyzed is representative of the current process status.

- The sample handling system should eliminate or minimize "dead volumes" and areas in the flow path where new sample can be mixed with old sample.

- Air and other gas supplied to the analyzer must be filtered and meet specified requirements.

- **All cautions and warnings in this manual, on tags and in other publications pertaining to the installation, operation and maintenance of the analyzer must be read and observed. Failure to consider the warning and caution messages can lead to severe personal injury, equipment damage and/or void of the warranty.**

- Instrument should be sheltered from direct sun or rain. If the instrument is to be used for very low ppm concentrations, it should be located in a climate controlled area. Ambient temperature should be between -20°C to +40°C (-4°F to +104°F).

Warnings and Cautions

This manual provides caution and warning messages as listed below. Failure to consider these messages can lead to severe personal injury, instrument damage and/or void of warranty.

WARNING:	**POWER MUST NOT BE RESTORED UNTIL ENCLOSURE HAS BEEN PURGED FOR 10 MINUTES WITH AN INPUT PRESSURE OF 30 PSIG.**
WARNING:	**A SEVERE ELECTRIC SHOCK HAZARD MAY EXIST WHEN POWER IS APPLIED WHILE SERVICING INTERNAL COMPONENTS.** Ensure that power lines are removed from the power source before continuing.
WARNING:	**A POTENTIONALLY LETHAL ELECTRICAL SHOCK HAZARD EXISTS WHEN CONTACT IS MADE WITH THE 120VAC LINE COMPONENTS.** Do not attempt to repair or test the 120VAC section without using the appropriate test meter with insulated probes.
WARNING:	**AN EXPLOSION DANGER EXISTS WHEN THE DOOR TO A POWERED ENCLOSURE IS OPENED WITHOUT FIRST DETERMINING THE SAFETY CLASSIFICATION OF THE OVEN AND THE TYPE OF GASES IN THE AREA.** The area must be known to be non-hazardous before a powered enclosure is opened. Follow the procedures for opening and closing a powered enclosure.
WARNING:	**A POOR GROUND CONNECTION MAY PRESENT A SEVERE SHOCK HAZARD.**
WARNING:	**HIGH-PRESSURE GASES SHOULD BE HANDLED WITH EXTREME CARE.** Ensure that all relevant safety precautions are carefully followed and all gas lines, regulators, gas purifiers, etc. are specified for the intended use.
WARNING:	**A PUNCTURE INJURY MAY RESULT IF THE WAGO CONNECTOR INSERTION TOOL IS ALLOWED TO SLIP DURING THE INSERTION PROCESS.** Some force is required to insert the WAGO tool completely into the connector. When possible, use a vice to hold the connector during insertion.

WARNING:	**IF THE SPECIFIED OPERATING PRESSURE CANNOT BE MAINTAINED, THE SOURCE OF THE LEAK MUST BE CORRECTED BEFORE CONTINUING WITH INSTALLATION AND OPERATION.** Ensure the sample and main gas flow is leak free by performing a leak test.
WARNING:	**EYE INJURY CAN RESULT WHEN HANDLING THE GLASS COMBUSTION TUBE.** Wear appropriate eye protection during service, removal and replacement of the combustion tube.
WARNING:	**PERMANENT EYE DAMAGE CAN OCCUR DUE TO LOOKING DIRECTLY INTO AN ILLUMINATED UV LIGHT SOURCE.** Wear appropriate eye protection when looking directly into a UV light source.
WARNING:	**SEVERE BURNS CAN RESULT WHEN WORKING AROUND A HOT COMBUSTION TUBE.** Allow the combustion tube to cool before performing maintenance.
WARNING:	**SEVERE BURNS CAN RESULT WHEN WORKING AROUND A HOT FURNACE.** Allow the furnace to cool before performing maintenance.
WARNING:	**AN ELECTRICAL SHOCK HAZARD MAY EXIST AND SEVERE COMPONENT DAMAGE MAY OCCUR WHEN USING A LIQUID LEAK DETECTOR.** Even though the solution in an approved liquid leak detector "Snoop" solution is non-conductive, care should be taken not to wet any electrical or electronic components.
CAUTION:	**Most liquid leak detectors contain sulfur compounds that can contaminate the gas supply line and instrument flow path components. Care should be taken not to wet or contaminate the analytical flow system when using a liquid leak detector.**
CAUTION:	**Become familiar with the location and use of all controls, indicators, connections and accessories and carefully read all instructions and warning labels prior to operating any portion of the system.**
CAUTION:	**The FGA 1000 should be sheltered from direct sunlight and precipitation exposure.**
CAUTION:	**Carefully ensure the system is leak free. Failure to do so may cause severe system component damage.**
CAUTION:	**Instrument Air for the sample injection and Parker valves must be set to a pressure of 70 psi. Lower activating pressure may result in improper actuation while higher pressure may cause damage to these valves.**

CAUTION:	**Line Voltage to analyzer must be supplied from an External Power Breaker with the specified current and voltage properties.**
CAUTION:	**All seals <u>MUST</u> be poured before energizing the unit.**
CAUTION:	**Follow Installation Drawings and Schematics in this manual to bring the unit on line.**
CAUTION:	**Do not attempt to operate the FGA 1000 until all installation and setup procedures outlined in the previous listed sections of this manual have been successfully completed.**
CAUTION:	**Serious instrument damage can result if the FGA 1000 is not fully functional and/or if the operator is inexperienced with the computer control.**
CAUTION:	**The glass combustion tube is easily broken during removal of the transfer tube fittings. Care must be taken not to apply pressure to the glass tube when removing the transfer line.**
CAUTION:	**The glass combustion tube inlet and outlet connection points are easily broken during removal. Care must be taken not to allow force to be applied to the tube when removing these connections from the glass combustion tube.**
CAUTION:	**Do not over tighten fittings. Over-tightening can cause restrictions, which will affect instrument performance. If ferrules need replacement, the fittings should be tightened according to the standard industry practice.**
CAUTION:	**The Excimer UV lamp is extremely fragile. Extreme care should be taken with these lamps to avoid breakage.**
CAUTION:	**Ensure that all interconnections are properly installed. Improper connections may cause damage to system components when power is applied.**
CAUTION:	**The Photo Multiplier Tube (PMT) is extremely light sensitive. Any exposure to ambient light with PMT power applied will result in extreme damage to the PMT. As a result, power to the PMT should always be turned off before exposing the PMT window to any ambient light.**
CAUTION:	**Ensure all inlet and outlet openings are kept clean and free from contaminants. It is recommended that the inlet and outlet openings be covered with tape when not connected to lines.**

CAUTION: **Do not exceed recommended pressures. If higher pressures are used, severe and irreparable damage may be done to fragile system components.**

Warranty

ATOM Instrument FGA-1000 Standard Warranty

Atom Instrument warrants that all products supplied will be of merchantable quality and will comply with the specification agreed for them.

Atom Instrument guarantees for a period of twelve months from installation of the product or fifteen months from delivery to the customer, whichever is the shorter, all Products and spare parts sold hereunder.

ATOM Instrument will repair or replace defective and/or nonconforming parts without charge for material or labor service during the warranty period.

Products that have been repaired or replaced during the warranty period are themselves warranted only for the remaining portion of the original one (1) year.

Repairs, adjustments and service performed after the expiration of the one (1) year warranty period shall be charged to the owner/purchaser at the then current prices for parts, labor, and travel related expenses.

Exceptions to this warranty are:

- Defects, damage, or nonconformity resulting from abuse, misuse, neglect, lack of reasonable care, unauthorized modification, or the attachment of improper devices to the products.
- Installation, operation and maintenance of the products in a manner that does not meet ATOM Instrument specifications will void this warranty.
- All requests for service or repair under this warranty must be received within the warranty period by ATOM Instrument or its authorized representative.

The warranties contained in this agreement are in lieu of all other warranties, expressed or implied, including the warranties of merchantability and fitness for a particular purpose.

Statements made by any persons, including representatives of ATOM Instrument, which are inconsistent or in conflict with the terms of this warranty shall not be binding upon ATOM Instrument unless reduced to writing and approved by an officer of the company.

Liability covered under this warranty is limited to the original cost of the ATOM Instrument supplied equipment. ATOM Instrument will not be liable for consequential damages including but not limited to loss of production, throughput or off specification product due to user or equipment error.

This warranty shall be governed by and construed in accordance with the laws of the State of Texas.

Spare Parts List

Recommended Consumable Spare Parts List

Part Number	Description	Quantity
60064-00001	FGA Online Combustion Tube, 10.75 L	1
60038-00001	Combustion Furnace	1
60097-10005	Assy, Thermocouple, Single S Type	1
23058-00001	Valve, 6-Port External Sample Injector, High Temp-Air Actuator	1
11228-00001	Dryer, .110" ID, 72" L, Fluorocarbon Fittings	1
60008-10001	Excimer Lamp Envelope	1
10027-00001	Ferrule, Standard 1/4", Graphite, (2/Pk)	6

Recommended Replacement Spare Parts List

SAMPLE ENCLOSURE SECTION

23058-00001	1	SAMPLE VALVE, 6-PORT
60062-00001	1	VALVE, 2-STREAM SWITCH, SSO/ARV
11258-00001	1	THERMOCOUPLE, TYPE K, 6" LONG
10027-00002	1	FERRULE, 1/8", VESPEL (10/PK)
23040-00001	1	FLOWMETER, SAMPLE ENCL
60037-10001	1	ASSY, HEATER, SAMPLE ENCL

COMBUSTION FURNACE SECTION

60038-00001	1	FURNACE, ONLINE ANALYZER
60097-10005	1	ASSY, THERMOCOUPLE, SINGLE S

COMBUSTION KIT - INCLUDES:

60064-00001	1	COMBUSTION TUBE
10027-00001	1	FERRULE, 1/4", GRAPHITE (2/PK)
23251-00001	1	TUBE, TEFLON, 1/8" O.D x 1/16" I.D (10FT/PK)
23252-00001	1	FERRULE, SET, 1/8" (10/PK)

MAIN ENCLOSURE SECTION

23248-00001	1	COMPUTER, TOUCH SCREEN, 12IN
60203-10001	1	ASSY, COMPUTER SCREEN PROTECTOR
23135-00001	1	Z-PURGE
60037-10002	1	ASSY, HEATER, ELECTRONICS ENCL
11572-00001	1	VALVE, SOLENOID, 3-WAY
11572-00002	1	VALVE, SOLENOID, 4-WAY

60087-WC017	1	ASSY, CABLE, SOLENOID VALVE
11478-00001	1	CONNECTOR, DIN, MANIFOLD, 24VDC
23242-00001	1	PRESSURE SWITCH ASSY, ADJUSTABLE, 4-125 PSI, 7A, 250V
23245-00001	1	MASS FLOW CONTROLLER, AIR 500 SCCM
11506-00001	1	TEMPERATURE CONTROLLER, SSR OUT, 24V
11280-00001	1	SOLID-STATE RELAY (SSR), 25A, 240 VAC
11233-00001	1	UNIVERSAL SIGNAL CONDITIONER, 24V, 4-20 MA OUT
11224-00001	1	THERMOCOUPLE, 30 AWG TYPE K, PFA
11262-00001	1	THERMOSTAT, 1/2" DIS, AUTO RESET, 15A OPEN@ 48.9C, CLOSE@ 32.2C
11525-00001	1	SOLID-STATE RELAY (SSR), 5VDC, DIN MOUNT
11526-00001	1	RELAY, 24V, DIN MOUNT
23123-00001	1	POWER SUPPLY, 24V, 4.2A, 100W, DIN RAIL
60078-10001	1	SP-2000 SIGNAL PROCESSOR BOARD PCA
60059-10001	1	EXTERNAL INTERFACE BOARD PCA
60079-00004	1	DC/DC CONVERTER, QUAD 24/5V,+15V,-15V,12V
60003-10001	1	DETECTOR WITH PMT
60008-10001	1	EXCIMER LAMP ENVELOPE
60001-10001	1	EXCIMER LAMP ASSY
11228-00001	1	DRYER, .110" ID, 72" L, FLUOROCARBON FITTINGS
23109-00001	1	REGULATOR, AIR, 0-60 PSIG

FGA-1000 Preventive Maintenance Schedule

Recommended schedule for parts replacement *

2 years **

PART NUMBER	DESCRIPTION
60097-10005	ASSY, THERMOCOUPLE, SINGLE TYPE S
60064-00001	COMBUSTION TUBE
10027-00001	FERRULE, 1/4", GRAPHITE (2/PK)
23058-00001	VALVE, 6-PORT SAMPLE INJECTOR, HIGH TEMP

4 years **

PART NUMBER	DESCRIPTION
60038-00001	FURNACE, ON-LINE ANALYZER
60097-10005	ASSY, THERMOCOUPLE, SINGLE TYPE S
60064-00001	COMBUSTION TUBE
10027-00001	FERRULE, 1/4", GRAPHITE (2/PK)
23058-00001	VALVE, 6-PORT SAMPLE INJECTOR, HIGH TEMP

6 years **

PART NUMBER	DESCRIPTION
60008-10001	ENVELOPE, EXCIMER, UV LAMP
60097-10005	ASSY, THERMOCOUPLE, SINGLE TYPE S
60064-00001	COMBUSTION TUBE
10027-00001	FERRULE, 1/4", GRAPHITE (2/PK)
23058-00001	VALVE, 6-PORT SAMPLE INJECTOR, HIGH TEMP

* *these are the minimum recommended replacement intervals and are based on customer provided data; customers are urged to use their discretion to choose schedule for parts replacement*

** *this only lists typical recommended parts, any other parts if needed, will be additional- please take this into account when planning for budgetary purposes*

Section 1 – Principle of Operation, Specifications, and Drawings

Section 1.1 Principle of Operation

The ATOM FGA-1000 has the highest dynamic measurement range of any commercially available analyzer without the need for additional sample valves, calibration gases or system hardware. In addition, the ATOM FGA-1000 does not require installation in a controlled environment shelter.

The ATOM FGA-1000 is an online process analyzer utilizing patented Excimer UV Fluorescence (EUVF) technology to measure Total Sulfur in a variety of applications such as monitoring refinery flare gas and subsequent sulfur dioxide (SO_2) emissions as mandated by the EPA Rule 40 CFR 60, Subpart Ja.

The UV Fluorescence method (UVF) is one of the most simple and practical low-level sulfur analytical techniques that has been widely used and proven over many years of industrial utilization. The UV Fluorescence method involves injection of a sample into a high-temperature oxidation or combustion furnace, which converts all hydrocarbons into water (H_2O) and carbon dioxide (CO_2) byproducts. Total Sulfur content contained in any molecular-bound hydrocarbon species is similarly oxidized at temperatures in excess of $1000°C$ into sulfur dioxide (SO_2) by the reaction:

$$R\text{-}SH + O_2 \rightarrow SO_2 + CO_2 + H_2O$$

The furnace effluent containing these combustion byproducts is directed into a detection chamber where it is excited by high-energy, short-wavelength emission from a UV excitation source. The UV photons from the excitation source or lamp, transfers energy into the SO_2 molecule and raises its energy level to create an excited singlet state. These excited molecules rapidly decay back to their lower energy ground state releasing the absorbed energy as a secondary emission known as fluorescence.

$$SO_2 + h\upsilon \rightarrow SO_2* \rightarrow SO_2 + h\upsilon'$$
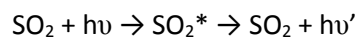
This low-level fluorescence emission is optically filtered to remove undesired wavelengths of the UV source and background scatter within the detector chamber. Detection of the filtered fluorescence emission is usually accomplished with a Photomultiplier Tube (PMT), Channel-Plate Multiplier (CPM) or other high gain, light-sensitive detector.

Section 1.2 Specifications

Analytical Performance

Measurement Method	Total Sulfur by Excimer UV Fluorescence (EUVF)
Measurement Range	0 - 100% (As required for specific Flare Application)
Repeatability	50ppm SD or ±2% of measured value, whichever is greater
	25ppm SD with 5-min. averaging
Linearity	±2% of full scale (Dynamic Range Dependent)
Response Time	100 sec. to 99% of new value
Calibration	Automatic or manual

Analog/Discrete Data Communications

Analog Outputs	Two 4-20 mA DC (optional)
Alarm Outputs	One global dry contact triggered by one or more of the following: Power Failure, Loss of Purge, Low Oxidizer Pressure, User-configured Digital Inputs (DI4 – DI7)
Digital Data Communications	RS-232, RS-485/422 MODBUS (TCP/IP optional)
Local MMI	12" Touchscreen Computer with Embedded Windows 7 allows complete operation and control of all analyzer functions
Remote Interface	Complete control of ATOM FGA, including monitoring of analysis parameters and digital data values

Utility Requirements

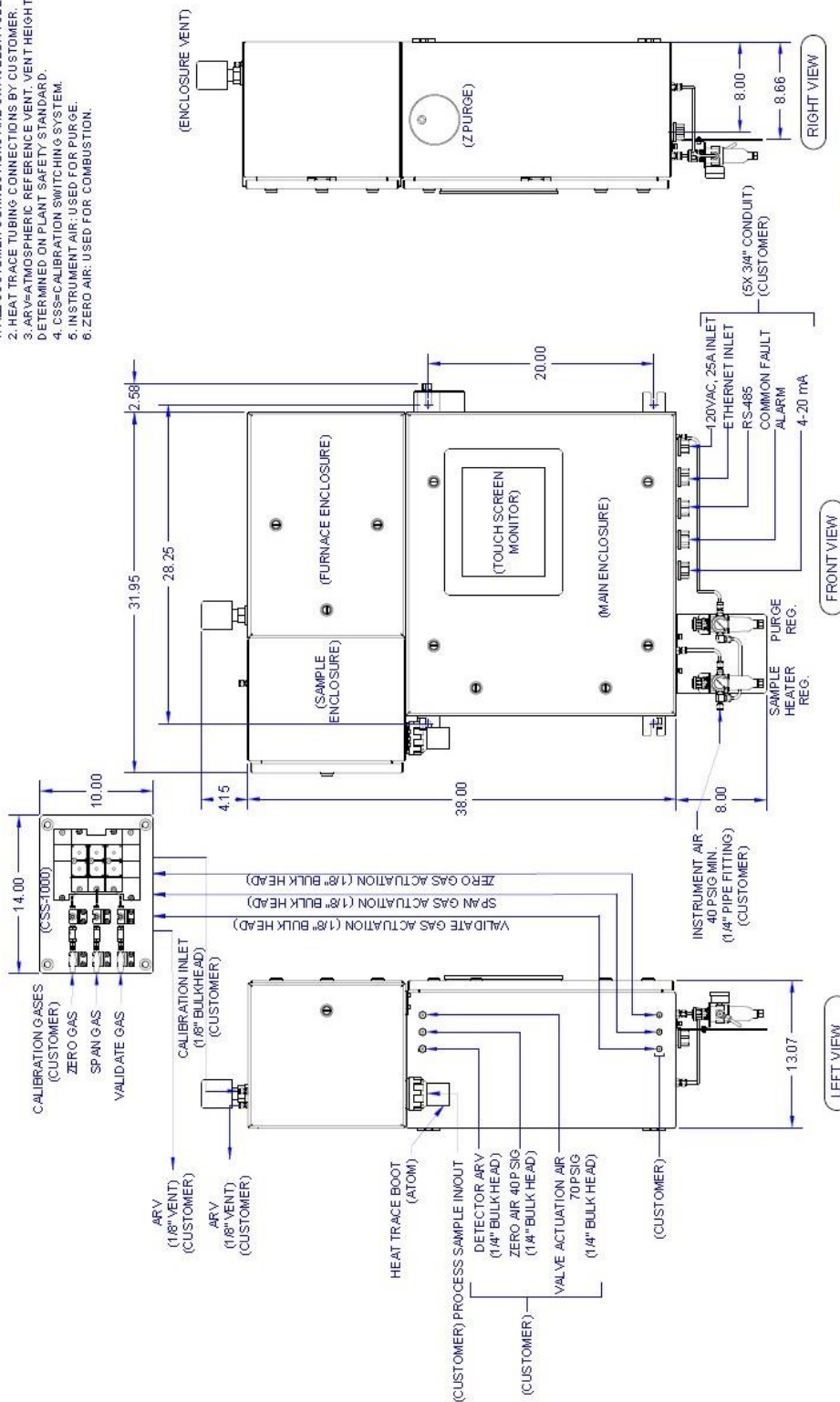|	
Ambient Temperature	-20°C to +40°C (-4°F to +104°F)
Power	120 VAC, 25 A, 50/60 Hz at 3000 watts
Instrument Air	70 psig (4.8 bar), 7 SCFM, Oil Free, -40°C (-40°F) dew point
Zero Grade Air	40 psig (4.8 bar), 200 SCCM

Physical Parameters

Dimensions	965.2 mm (38.0 in) high x 660.4mm (26.0 in) wide x 304.8 mm (12.0 in) deep
Mounting	Wall or Unistrut Stand

Section 1.3 FGA-1000 Drawings

Section 1.3.1 Installation Drawings

Section 1.3.2 Process Flow

Section 1.3.4 Calibration Switching System
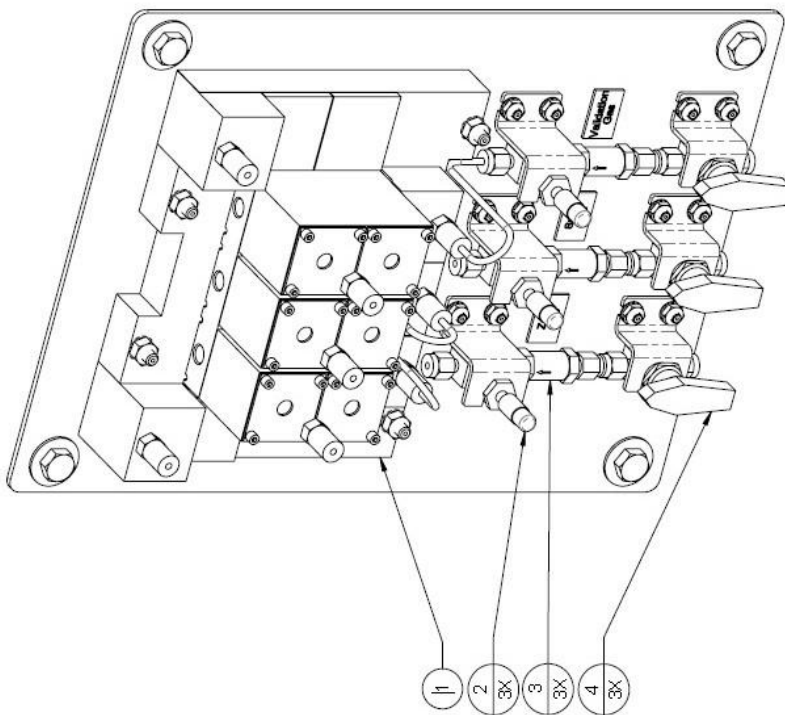
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	60062-00002	VALVE, DOUBLE BLOCK BLEED, EXTERNAL	1
2	23257-00001	VALVE, METERING, 1/8 IN	3
3	23124-00001	FILTER, 1/8	3
4	23254-00001	VALVE, BALL, 2-WAY, 1/8	3

TITLE: **CALIBRATION SWITCHING SYSTEM, CSS-1000**

ATOM Instrument
HOUSTON, TX, USA

JOB: N/A
SCALE: NONE
DWG NO: **60065-00001**
REV: 1
SHEET: 1 OF 1

DRAWN BY: HARISH B
DATE: 07/08/14

Section 1.3.5
Main Enclosure

ITEM NO.	PART NUMBER	DESC	
1	11228-00001	COMPUTER, T01	1
2	23248-00001	Z-PURGE	1
3	23135-00001	HEATER, MAIN, CONNECTORIZED	1
4	60037-00002	HEATER, SAMPLE, CONNECTORIZED	1
5	60037-00001	SOLENOIDS, 4-WAY	1
6	11572-00002	SOLENOIDS, 3-WAY	6
7	11572-00001	CONNECTOR, DIN, MANIFOLD, 24VDC	7
8	11478-00001	PCBA, DETECTOR	1
9	SP-2000	DC-DC CONVERTOR	1
10	PS-512-15X2	DETECTOR WITH PMT	1
11	60003-10001	ASSY, LAMP, EXCIMER	1
12	60001-10001	CONTROLLER, MASS FLOW	1
13	23245-00001	FILTER, 1/8	1
14	23124-00002	PRESSURE SWITCH	1
15	23242-00001	POWER SUPPLY, 24V	1
16	23123-00001	PCB, EXTERNAL INTERFACE	1
17	60069-00001	RELAY, DIN MOUNT	2
18	11528-00001	SSR, DIN MOUNT	1
19	11525-00001	SIGNAL CONDITIONER	2
20	11233-00001	TEMPERATURE CONTROLLER	3
21	11506-00001	THERMOSTAT, MAIN ENCLOSURE	1
22	11262-00001	SSR, HEATER	3
23	11280-00001	CIRCUIT BREAKER, 240V, 25A	1
24	11507-00002	FILTER, EMI, 250 VAC, 10A, DIN RAIL	1
25	23136-00001	CIRCUIT BREAKER, 240V, 5A	2
26	11507-00001		2
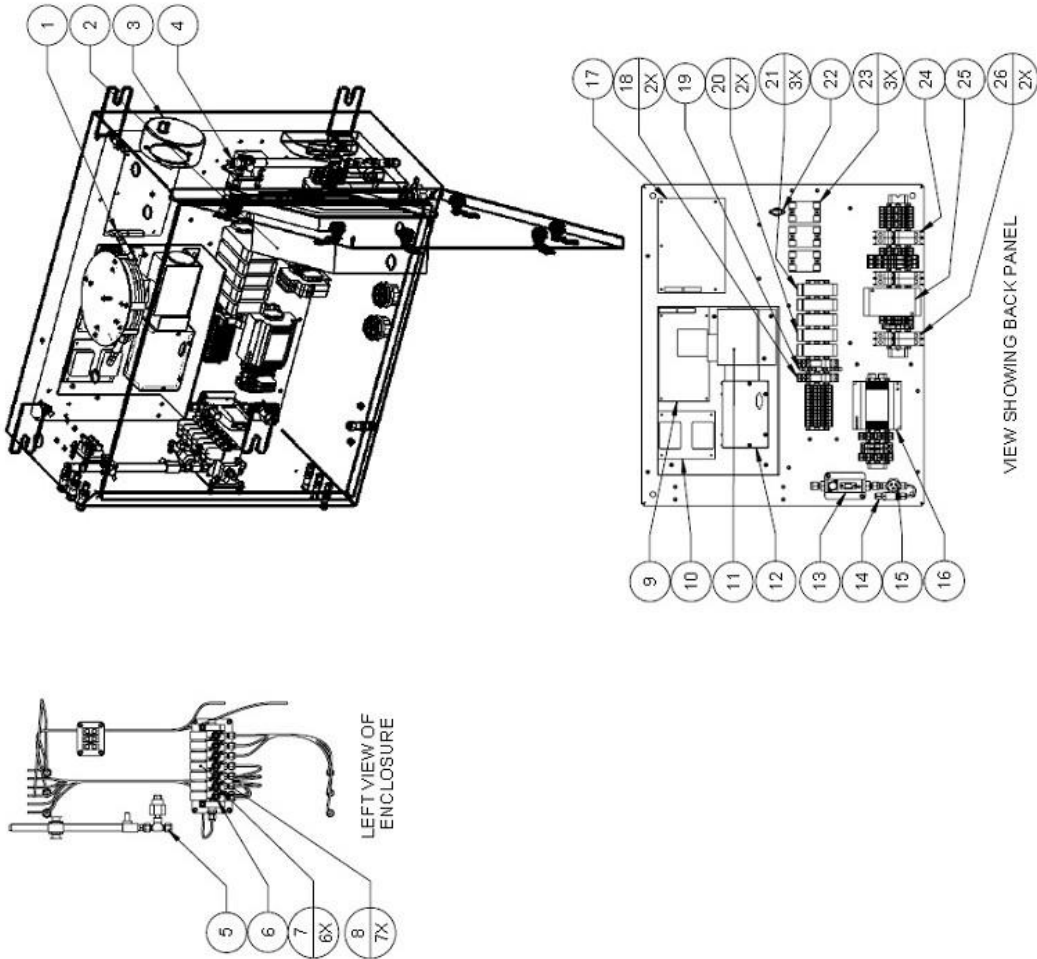
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DWG NO: 60045-00001   REV: 3   SHEET: 1 OF 1

SCALE: NONE   DRAWN BY: HARISH B   DATE: 08/12/14

JOB: N/A   ATOM Instruments   HOUSTON, TX

LEFT VIEW OF ENCLOSURE

VIEW SHOWING BACK PANEL

Section 1.3.6 Furnace Enclosure
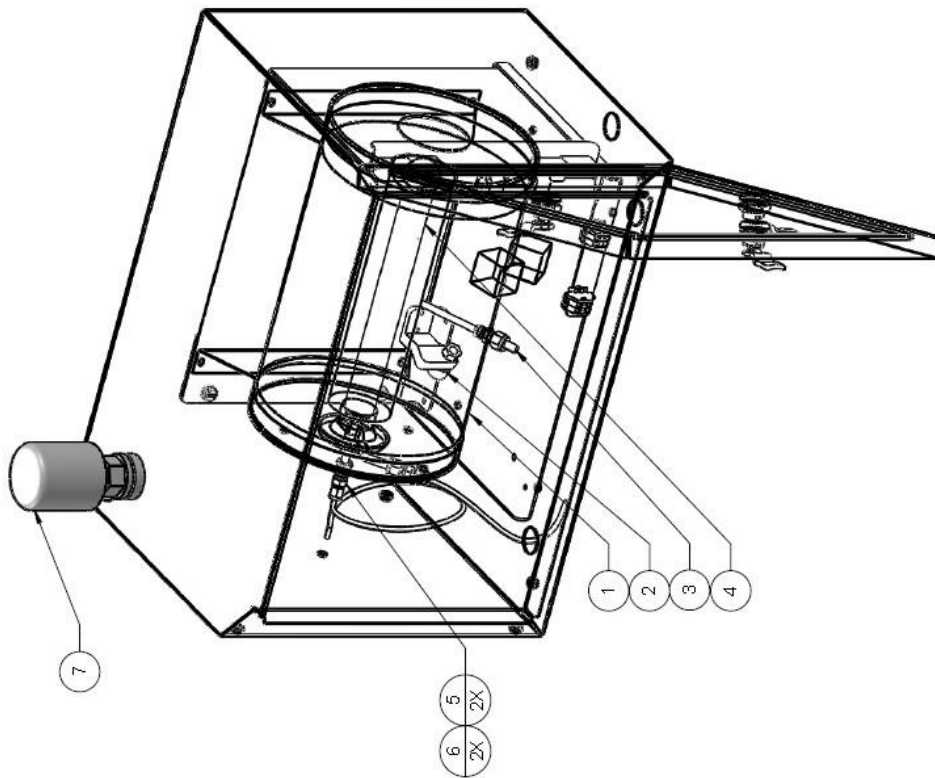
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1	60038-00001	FURNACE, 8IN	1
2	11003-00001	ROLLER, FURNACE	1
3	11261-00001	THERMOCOUPLE, FURNACE ENCL	1
4	60064-00001	COMBUSTION TUBE, 10.75L	1
5	23253-00001	FITTING, REDUCING UNION	2
6	10027-00001	FERRULE, 1/4	2
7	11254-00001	VENT, FURNACE ENCL	1

TITLE: **COMPONENTS, FURNACE ENCLOSURE, FGA-1000**

DWG NO: **60040-00001** REV: 3

SCALE: NONE SHEET: 1 OF 1

DRAWN BY: HARISH B DATE: 08/12/14

JOB: N/A

HOUSTON, TX

Section 1.3.7 Sample Enclosure
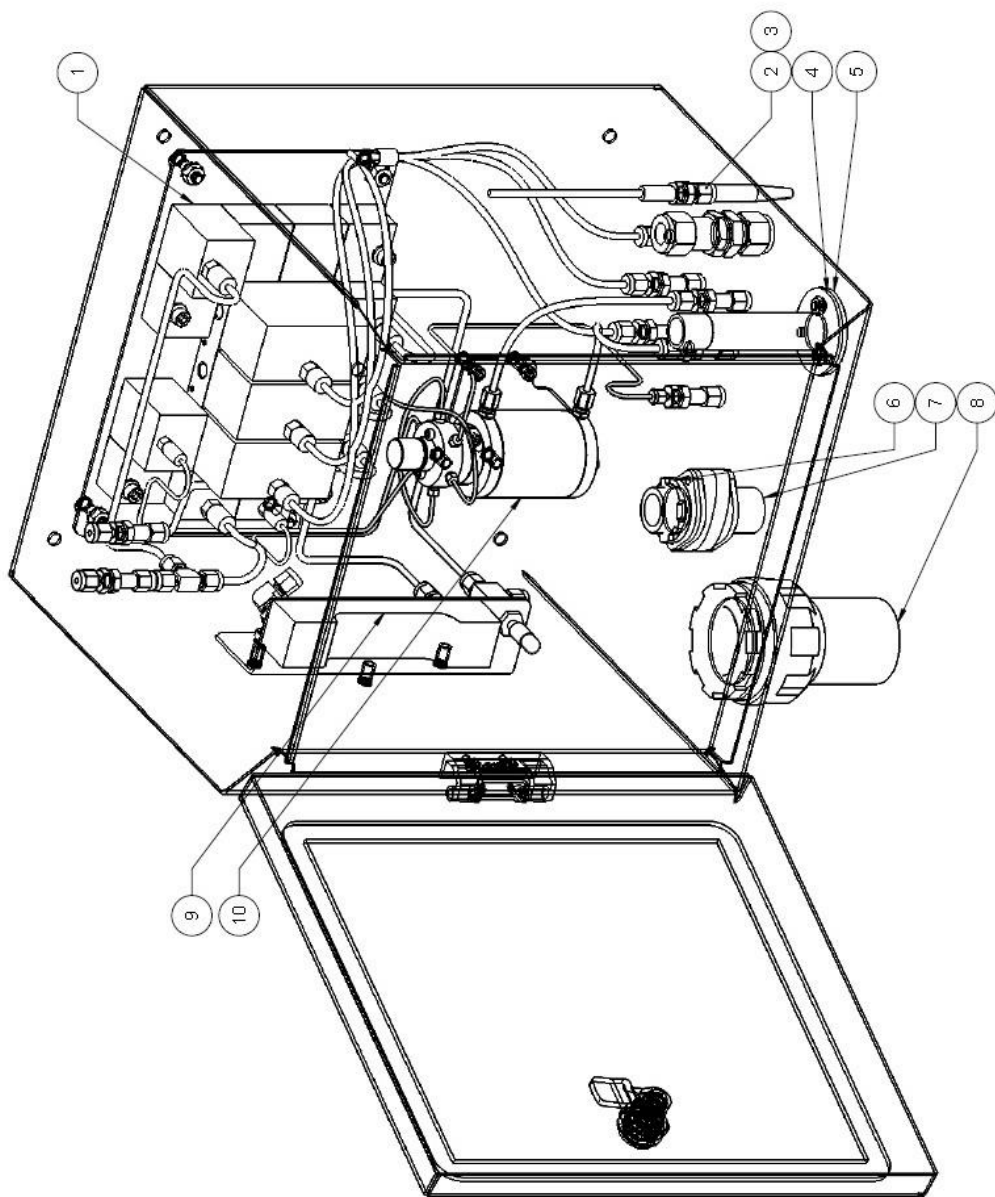
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	60062-0001	VALVE, DOUBLE BLOCK BLEED, INTERNAL	1
2	10027-0002	FERRULE, 1/8, VESPEL	1
3	11298-0001	THERMOCOUPLE, SAMPLE ENCL	1
4	60069-0001	GASKET, VENT, SAMPLE ENCL	1
5	11234-0001	VENT, SAMPLE ENCL	1
6	11235-0001	LOCK NUT, 3/4" CONDUIT HUB	1
7	23099-0001	GLAND, CABLE	1
8	23107-0001	BOOT, HEAT TRACE TUBE	1
9	23040-0001	FLOWMETER, SAMPLE ENCL	1
10	23058-0001	SAMPLE VALVE	1

TITLE: **SAMPLE ENCLOSURE, FGA -1000**

ATOM Instrument
HOUSTON, TX, USA

SCALE: NONE	DWG NO: **60035-00001**	REV: 2
JOB: N/A		SHEET: 1 OF 1
DRAWN BY: HARISH B	DATE: 08/12/14	

Section 2 – Software Operation

This section of the manual is intended to provide a complete overview of the FGA-1000 software providing the user a fundamental understanding of analyzer operation.

There are 3 programs incorporated into FGA-1000 software that have distinct functions, but work together to provide complete control and user interface of the FGA-1000 instrument. The main FGA-1000 software program operates in the background and controls all aspects of analyzer operation, which includes protocols for communicating with the detector module. The detector module firmware is a distinctly separate, machine-language program embedded in the onboard microprocessor. The third program is a colorful, high-contrast Graphical User interface or GUI that provides a user-friendly interface comprised of an organized set of intuitive menu screens that are configured for ease of use.

Start Up

Upon powering up the FGA-1000, the touchscreen will begin to turn on and Windows 7 will boot. If an administrator password has been set up for Windows 7, the password can be entered using an external keyboard plugged into a USB port to access the software. If no keyboard is connected, the touchscreen keyboard can be displayed by pressing the "Ease of access center" button at the bottom left of the screen and then selecting the "Type without the keyboard (On-Screen Keyboard)" option.

If no Windows administrator password has been implemented, the main GUI menu (*Figure 2.1)* will open automatically after the FGA-1000 and touchscreen computer are powered on. All sub-menus may then be accessed from this bar found at the top of the desktop screen.

Figure 2.1 – Main Menu

In order to access any of the sub-menus of the GUI, the user must first log into the system. Refer to section 2.1.1 for Login information
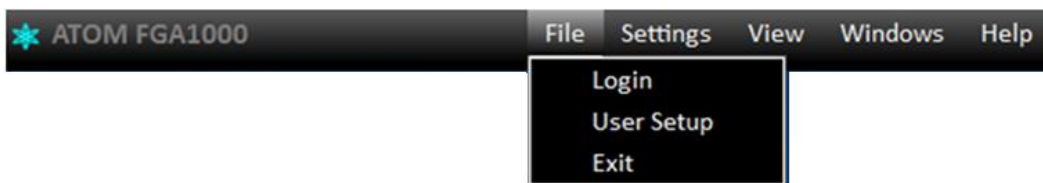
Section 2.1 File Menu

Figure 2.2 – File Drop down Menu

Section 2.1.1 Login

The **Login** feature allows users to interface with the software on two separate levels. Users without administrative privileges are limited to menu access for viewing purposes only. Those users with administrative privileges have complete access to all menu settings, which can be modified as necessary for customizing or optimizing instrument operation (selectable in User Setup, *Figure 2.6*). The **Login** feature is intended to prevent unauthorized changes to instrument operation, allowing it to retain current settings unless an authorized user logs in with valid credentials *(Figure 2.3)*.

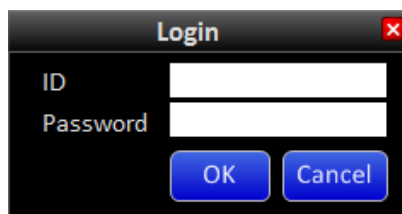To log in to the analyzer, click **File > Login**. Press the ID line.

Figure 2.3 – Login Screen

A touchscreen keyboard should automatically pop-up on the screen *(Figure 2.4).*

Figure 2.4 – Touchscreen Keyboard

Using the touchscreen keyboard, enter the username ID. Then press the Password line and enter the user assigned password. After proper user credentials have been entered, press the OK button to complete the Login process.

NOTE: Any attempt to access a screen that requires administrative privileges, the **Login** screen will automatically pop-up and prompt the user for the required credentials.

NOTE: The dropdown menu will read Logout if a valid login has already been entered *(Figure 2.5)*.

Figure 2.5 – User Already Logged In
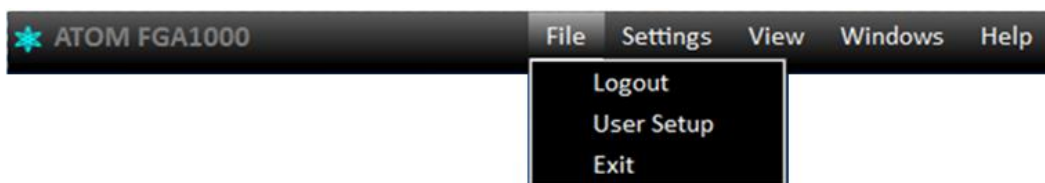
There is an auto-logoff feature in place to automatically logout any user after 15 minutes of inactivity. After this time, any screen that requires administrative privileges to change or modify settings will automatically cause the Login Screen to reappear and prompt the user to re-enter the required credentials.
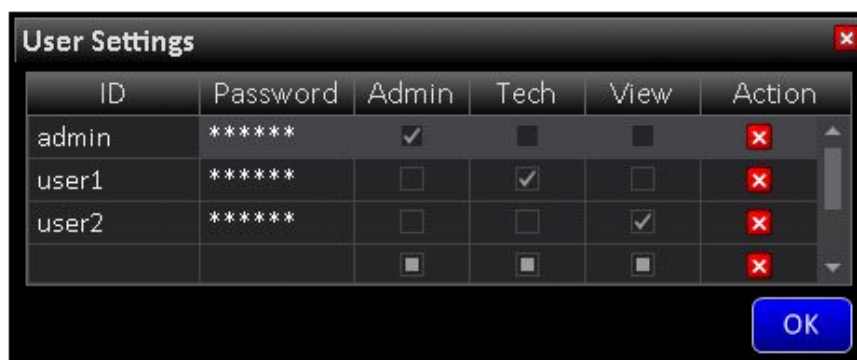
Section 2.1.2 User Setup

Figure 2.6 – User Settings Screen

The User Setup screen is accessed from **File > User Setup**. Three levels of user privileges are assigned and defined as Admin, Tech and View. Below is a description of each user's privilege:

	Admin	Tech	View
View any GUI screen	X	X	X
Modify analyzer parameters	X	X	
Modify user privileges	X		

When logged in as a system administrator, pressing the ⊠ will delete the corresponding user profile. The factory "admin" cannot be deleted nor can the name be modified. However, subsequent users with "Admin" privileges can be created or deleted. The administrator can add users and assign/change a user's privileges. To add a user, click on the last empty ID field and enter the user name, a password and then select user level (Admin/Tech/View) to finish user registration.

Section 2.1.3 Exit

By clicking **File > Exit**, the GUI program will close; however the FGA-1000 main program will continue to run if there are no operational restrictions, such as loss of purge or other system critical alarm function.
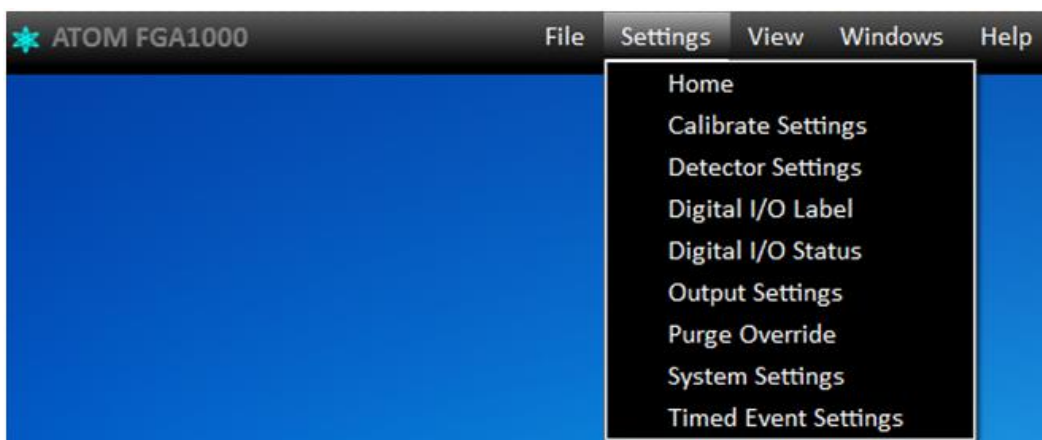
Section 2.2 Settings

Figure 2.7 – Settings Dropdown Menu

Section 2.2.1 Home

The Home Screen is the top screen in the Settings menu and is considered to be the primary user interface for an overview of routine analyzer operation. *(Figure 2.8)*. The Home menu functions are arranged in groups and are discussed separately.
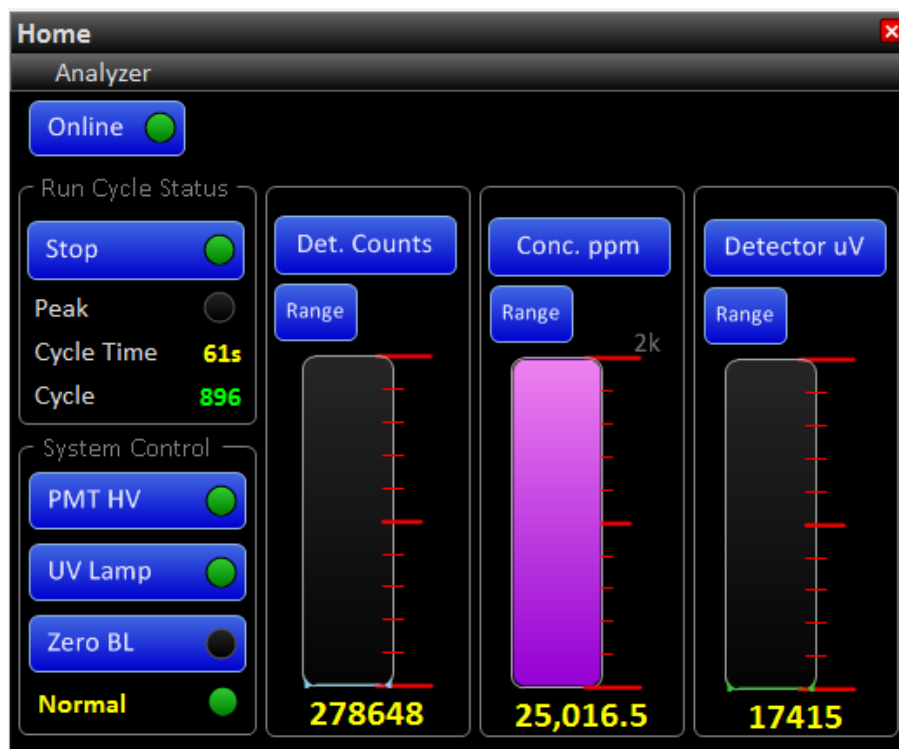
Figure 2.8 – Home Screen Detailed

Run Cycle Status

The Run Cycle Status section of the Home Screen displays information regarding various aspects of the Run Cycle in process

Start/Stop Button:
The analyzer software is designed so that the Analysis Cycle runs all the time, and will automatically restart upon restoring power after a power shutdown. Exceptions to the continuous run feature are:

1.   There is an Alarm condition.
2.   The Run Cycle is manually stopped.
3.   The analyzer is Purging due to an Auto Calibration Check, or return to Process.
4.   The analyzer is Holding as part of the Run Cycle Mode.

When the button is labeled STOP with a green LED, a cycle is either running, or is scheduled to run. Pressing this button will cause the cycle to stop after the current cycle has completed. When stopped, this button will be labeled START with the LED off. Pressing this button again will change the label to STOP and initiate a new cycle run.

Event Indicator
Beneath the START/STOP button is an indicator that displays various events related to the Run cycle. Some of the events the Event Indicator will display are, Not Ready, Holding and Purging. Whenever a cycle is currently running, it will display timed events as they occur such as Injecting, Baseline Evaluation and Peak Integration periods.

Cycle Time
The Cycle Time in the Run Cycle Status displays the current cycle time in elapsed seconds. The standard cycle time for the FGA-1000 is 100 seconds. Once the current cycle is complete, it will start a new cycle at time 0.

Cycle Number
The Cycle Number displays the total number of completed cycles the analyzer has run since the analyzer was started. This number will increase until the cycle is stopped and will continue to increase once the cycle has restarted. This number will only be reset on power down of the detector or analyzer.

System Control

The System Control section of the Home Screen shows the status of the PMT and UV Lamp voltages, the presence of any Zero baseline offset value, and status of the FGA-1000 alarm system.

PMT HV
This button controls high voltage to the Photo-Multiplier Tube and indicates whether it is ON or OFF. The LED will be GREEN if powered ON and is turned OFF by pressing the button to toggle.

UV Lamp
This button controls power to the Excimer Lamp Module and operates in similar to the PMT HV button in its ON/OFF functionality.

Zero BL
This button allows any baseline level to be zeroed for graphic display purposes, or the analyzer analog output when the detector signal is selected. This function must be enabled in the Detector Settings Screen which will be discussed later in the Software

Operation section. Zeroing the baseline level will not affect acquired results or calculations of total sulfur composition.

Analyzer Alarm Status

This line will display **Normal** with green LED when the analyzer is running properly. This line will display **Warning** with yellow LED when something on the FGA-1000 requires attention but is not critical enough to affect normal analyzer function. Should a system critical situation arise, this line will display **Alarm** with red LED indicating an alarm condition exists. If this occurs, the FGA-1000 is designed to stop the current Run Cycle, which may also include combustion furnace shutdown, and activate the Global Alarm. *(Figure 2.9)*
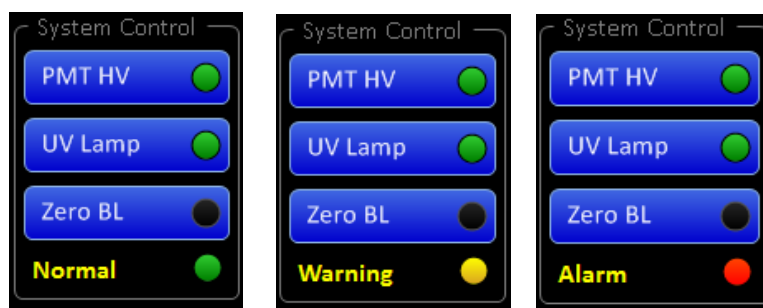

Figure 2.9 – Normal, Alarm, and Warning Status

NOTE: The status of this indicator will also be prominently flashed on the menu bar should the FGA-1000 go into either WARNING or ALARM mode.

Variable Display Section

The Variable Display section allows monitoring of up to three user selected variables with associated bar graphs whose ranges can be chosen as necessary to provide a customizable display, depending on customer preference. Although any combination of variables can be chosen, the graphs are set to Detector µV, Peak Area, and Conc. PPM , in *Figure 2.9*. These displays will hold their current value until a new value is calculated, replacing the old reading with the most recent one. Pressing any of the three buttons above the graphs will open a list of available display variables, which can be selected by highlighting the intended variable and pressing the **OK** button. *(Figure 2.10)*
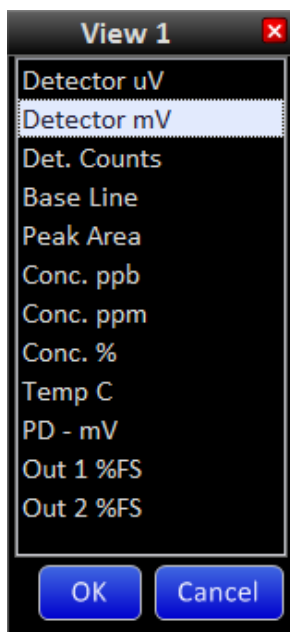
Figure 2.10 – Variable Display Selection Menu

Pressing the RANGE button allows the bar graph range to be selected in a likewise fashion. The desired range is chosen by selecting the adjacent radio button *(Figure 2.11)*. Alternatively, it is possible to choose a user defined range in the bottom last line of the table.
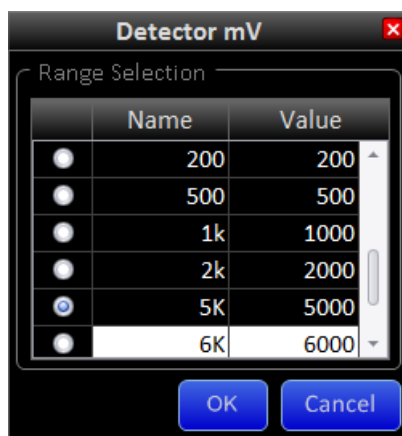

Figure 2.11 – Variable Range Selection Menu

Section 2.2.2 Calibrate Settings

The Calibrate settings screen *(Figure 2.12)* is where all information regarding instrument calibration and associated calibration results are displayed.

To access this screen press **Settings > Calibrate Settings**

Figure 2.12 – Calibrate Settings Screen

Check Cycle Status

The Check Cycle Status allows the user to monitor and review acquired Check Cycle results, as well as the progress of the Check Cycles in progress.

 View Results
Pressing the **View Results** button opens a separate menu and displays up to ten runs in a Cycle Set, allowing them to be viewed as they occur during Manual or Auto Check Runs. The results displayed are computed with the Response Factor (RF) currently in use *(Figure 2.13)*.

If a calibration check is in progress, results are updated in real-time as they occur. If the last calibration check is finished, these results will display all acquired values within the last calibration check set. Although "check calibration" results can be viewed at any time, they will be wiped clean and replaced with new data whenever the next Manual or Auto Check calibration is performed. Both Zero and Span sections display Area and Concentration values associated with the calibration check, as computed with the previously accepted Response Factor (RF).

Run	Zero		Span	
	Area	Conc %	Area	Conc %
1	0	0.00	309,236,128	50.36
2	0	0.00	308,633,134	50.26
3	0	0.00	306,712,151	49.95
4	0	0.00	304,737,106	49.63
5	0	0.00	306,421,694	49.90
6		0.00		0.00
7		0.00		0.00
8		0.00		0.00
9		0.00		0.00
10		0.00		0.00
Average	0	0.00	307,148,042	50.02

Figure 2.13 – Check Calibration Results Screen

Cycles Run

The Cycles Run Line indicates the number of completed runs from the number of cycles selected for the calibration check set.

Cycle Controls

The Cycle Control section of the menu allows the user to set the number of calibration cycles desired for each Check Calibration Set, as well as the amount of purge time between cycles.

Cycles/Set

The **Cycles/Set** button allows any number of cycles to be selected between 1 and 10 for the desired set of runs. This number of cycles will be applied to each Zero, Span or Validate samples when selected. By pressing the **Cycles/Set** button a window will pop-up as well as the touchscreen keyboard in order to enter the desired number of cycles to be run. Press OK to set this value. *(Figure 2.14)*
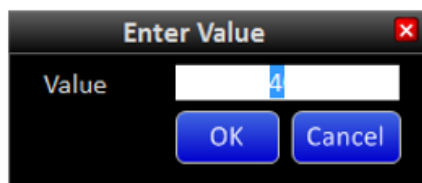
Figure 2.14 – Enter Value Screen

NOTE: The Enter Value Screen will pop-up throughout the software when required.

Purge (Sec)

The **Purge (Sec)** button allows the user to select the purge time between sets. This is intended to allow sample concentrations to reach equilibrium prior to starting a calibration check set. The optimal time setting will depend on sample flowrates and dead volume between the selection valves and analyzer.

The purge time will be applied during transition times between running process and a calibration check sample, between each set of calibration checks, and before returning to running the process sample.

If the analyzer is in purge mode, the Home Screen will display **Purging** on the event line and the clock counter will decrement from the chosen setting to "0" seconds.

** Note: A loss of purge will cause the analyzer to go into "Alarm", and the analysis is stopped immediately. If this Alarm event occurs right after sample injection, then this sample will still be present in the system even after the alarm condition clears. Once the Alarm is cleared, the analyses resume after purging for the set duration (**Purge (Sec)** set as shown above under Calibration Settings).

    If the purge is set for a shorter duration, it may not be enough to sweep the previously injected sample out of the system before the next sample injection. This increases the probability of system coking. To avoid this, it is *recommended that the Purge Time be set to a minimum of 60 seconds*.

Calibrate Values

This section displays all values used or associated with instrument calibration.

Check Zero and Span

The **Check Zero** and **Check Span** buttons display acquired values from the most recent calibration check. After the calibration checks are finished average calculated areas of Zero and Span will be displayed in these buttons. These values will be used for analyzer

recalibration if considered acceptable by the user. Calculated values can be overridden with any User specified value.

Saved Zero and Span
Values on these lines display previously accepted areas utilized for calibration purposes.

Zero and Span Concentrations
The **Zero Conc** and **Span Conc** buttons allow the user to enter known concentration of samples, generally utilizing the certified values provided by the calibration gas supplier. The **Cal Units** button allows the user to select the concentration for both values to be entered in either percent or PPM.

RF=Count/ppm
The RF=Count/ppm button displays the most current response factor. The response factor (RF) is primary number used to calibrate the instrument. The number represented as Counts/PPM is a value proportional to the difference in area divided by difference in concentration.

If modification to the calculated RF is preferred, or instrument performance utilizing a randomly selected RF without calibration is desired, the user merely presses the RF=Count/ppm button and enters the chosen RF.

Manual Check

The Manual Check section allows the user to manually run a ZERO, SPAN, or VALIDATE set of run cycles. The ZERO and SPAN functions will use the sample bottles that are connected to their respective inputs to calibrate the FGA-1000. The VALIDATE function will run any concentration of a known sample to ensure the FGA-1000 accurately measures the intended concentration.

Auto Check

The Auto Check section of the Calibration Settings allows the user to set up routine calibration checks.

The **Enable** button enables or disables auto check feature, as indicated by the embedded LED. Any or all of the three possible gas standards can be included in the Auto Check run by selecting the adjacent box to include a checkmark. The user can also specify the desired auto check schedule utilizing the **Freq (Days)** and **Time (24Hr)** buttons. The time of day is always entered in 24-hour format.

Demo Mode

The **Demo Mode** button allows the user to substitute previously recorded data in place of real-time detector data without having to run actual samples. The Demo Mode feature is enabled by pressing the button as indicated by the lit LED.

If the FGA is analyzing process sample when Demo Mode is enabled, normal detector signals will be substituted with pre-recorded data from a 50% concentration sample at the end of the current Run Cycle.

If the FGA is analyzing calibration sample, whether in Manual or Automatic mode, the 50% concentration sample data will be substituted whenever Span is selected.

If Zero gas is selected, a different set of pre-recorded data representing near-zero sample concentration will be utilized. If Validate is selected, pre-recorded data representing 25% total sulfur sample concentration will be utilized.

It is important to note that there are a total of 7 continuous runs recorded for each of the above pre-recorded concentrations. If more than 7 cycles are selected to run in a cycle set, the pre-recorded analysis data will merely repeat every 7 cycles, and include any portion thereof necessary to complete the intended set. The detector will return to processing normal real-time signals after DEMO mode is turned OFF.

Last Validation

This section of the menu shows the last validation the FGA-1000 performed with the date and time.

Calculate RF

After Manual or Auto Check is complete, the analyzer will display the new data for zero and span values in the "Check" section. Pressing the "Calculate RF" will automatically calculate the response factor based on the difference between Zero and Span areas from the latest Check Calibration run.

Save Calibration

Whenever any calibration check information has changed, such as completion of a calibration set, manual change to calibration check values, or a response factor that has either been calculated or manually entered, the **Save Calibration** LED will indicate new calibration values that remain to be entered. All changes will not come into effect until the **Save Calibration** button is pressed.

Section 2.2.3 Detector Settings

The Detector Settings screen contains information about the detector and settings that can be altered *(Figure 2.15)*.

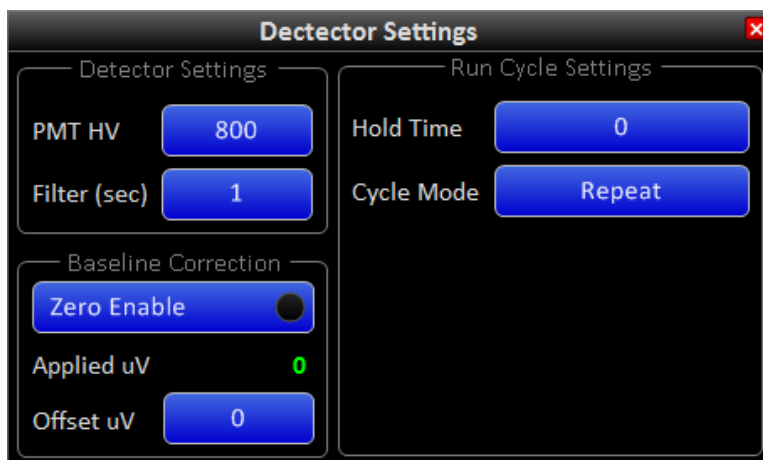To access this menu press **Settings > Detector Settings**

Figure 2.15 – Detector Settings Screen

Detector Settings

This part of the menu allows the user to change the PMT HV (Photo-Multiplier Tube High Voltage) and change the filtering constant of the data collected.

The PMT HV button lets the user change the high-voltage applied to the PMT to adjust detector sensitivity and associated peak height to the desired level. The PMT HV default value is 800V, but is typically modified as necessary at the factory. The maximum voltage setting is 1099 volts.

The Filter (sec) button controls the detector filtering constant, or a rolling "box-car" average of individual 1-sec detector count readings. The optimal setting for the FGA-1000 is 8 seconds for best results, which is a time constant that allows maximum smoothing of detector data without significantly affecting overall peak height.

Baseline Correction

This section allows the detector baseline to be modified as desired for graphing or output purposes.

The Zero Enable button allows the baseline to be zeroed either manually, or automatically. To turn this function ON press the Zero Enable button and the indicator will turn GREEN. To turn it OFF press the button again and the indicator will be BLACK.

Manual zeroing of the baseline is accomplished by pressing the Zero BL button in the System Control Section of the Home Screen. Automatic zeroing of the baseline is defined in the Timed Events Settings and will occur during the programmed time. Even if the Zero Enable button is enabled, a program time of "0" will prevent automatic zeroing of the baseline.

Applied µV

The Applied µV line displays the voltage applied to the normal detector baseline to shift it to zero. This value is cumulative each time the baseline is zeroed either manually or automatically. When the Zero Enable button is turned off, any cumulative offset value is dropped and the baseline will return to its normal state.

Offset µV

Whether the Zero Enable button is enabled or not, the Offset µV button allows the user to readjust the baseline to any desired value.
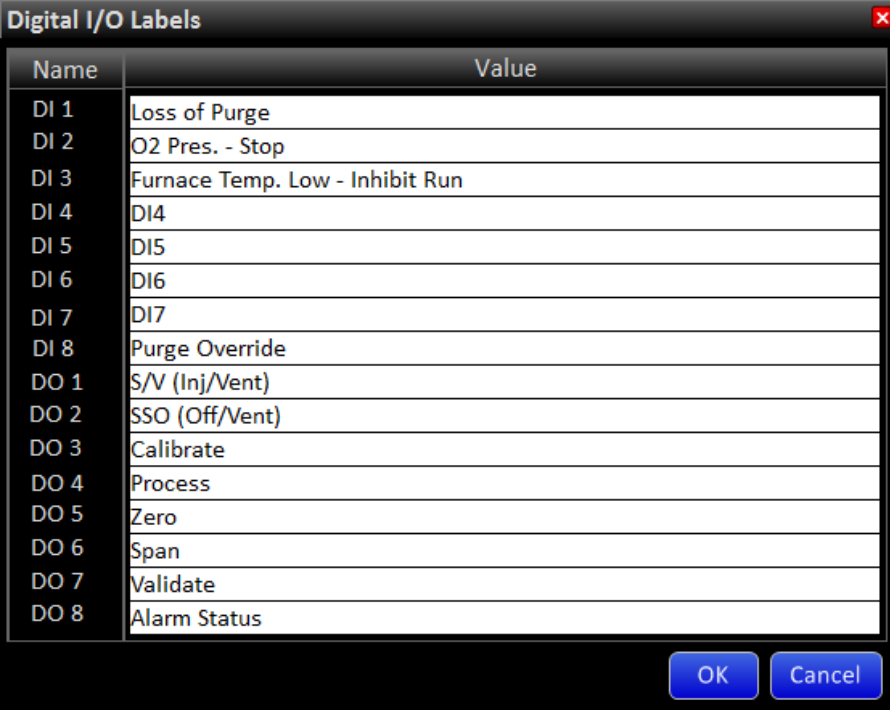
Run Cycle Settings

The Run Cycle Settings allow the mode of cycle operation to be selected. The three modes of operation are **Repeat**, **Hold** and **Stop**.

If the selected mode is **Stop**, a running cycle will stop at the end of programmed cycle time. If the selected mode is **Repeat**, a new cycle will immediately restart after the current cycle ends. If the selected mode is **Hold**, a new cycle will start after the Hold time has elapsed. Whether the analyzer is in Repeat or Hold modes, cycles will run continuously until a) the cycle is manually stopped; b) an alarm condition arises; or c) power to the analyzer is turned off.

Section 2.2.4 Digital I/O Label

The Digital I/O Label screen contains assigned names for all digital inputs and outputs *(Figure 2.16)*.

To access this menu press **Settings > Digital I/O Labels**

Name	Value
DI 1	Loss of Purge
DI 2	O2 Pres. - Stop
DI 3	Furnace Temp. Low - Inhibit Run
DI 4	DI4
DI 5	DI5
DI 6	DI6
DI 7	DI7
DI 8	Purge Override
DO 1	S/V (Inj/Vent)
DO 2	SSO (Off/Vent)
DO 3	Calibrate
DO 4	Process
DO 5	Zero
DO 6	Span
DO 7	Validate
DO 8	Alarm Status

Figure 2.16 – Digital I/O Labels Screen

The Digital I/O labels above have been assigned as default names by the factory. To change any of these, the text is selected by pressing the desired line, which will pull up the touchscreen keyboard. The user then enters any alternate name or text desired, and presses the **OK** button.

Section 2.2.5 Digital I/O Status.

The Digital I/O Status screen is consolidated screen to check the status of all the digital inputs and outputs *(Figure 2.17)*.

To access this menu press **Settings > Digital I/O Status**
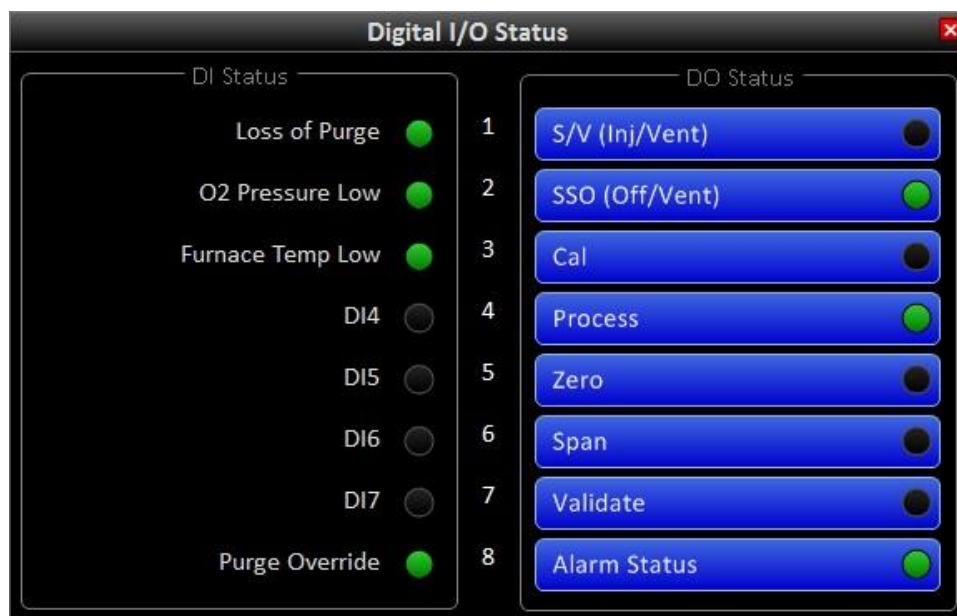

Figure 2.17 – Digital I/O Status Screen

<u>DI (Digital Input) Status</u>

This section displays the digital inputs in their normal operating state. Digital inputs 1-3 reflect the presence of system critical parameters that are described in the System Setting menu. Digital Inputs DI4 – DI7 are user configurable. All Digital Inputs DI1 – DI7 are "Open Contact" alarms, (i.e. the contacts open to indicate an alarm condition). In the event that an open input occurs on any Digital Input, and the Alarm box is checked, the system will trigger the Global Alarm. In this state, Digital Outputs DO3 – DO7 will be turned off and disabled, putting valve actuators in a cut-off state. The system will stay suspended in this cut-off state until the input generating the alarm is once again closed (alarm condition cleared).

<u>DO (Digital Output) Status</u>**.**

This section displays the status of all digital outputs as indicated by the associated LED. The digital outputs are configured as 24V DC signals that operate a variety of valves and relays from the External Interface board. When the analyzer is running, these outputs automatically turn on and off as required by timed events and calibration settings. For

troubleshooting purpose these outputs can be manually turned on and off, *only* if the analyses have stopped, no Alarm conditions exist, and the Analyzer is in "holding" state.

Section 2.2.6 Output Settings

The Output Settings screen allows the user to select the desired variable and scaling for both Analog Output channels available with FGA-1000 *(Figure 2.18)*.

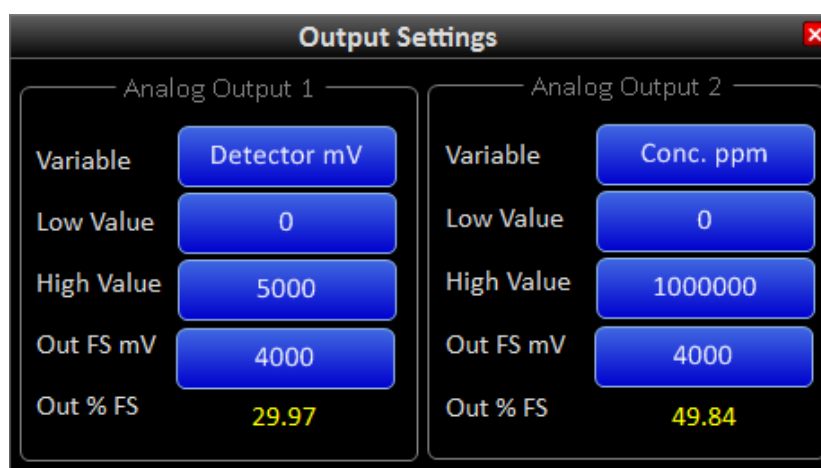To access this menu press **Settings > Output Settings**

Figure 2.18 – Output Settings Screen

The Output Settings menu is divided into two identical sections for Analog Output 1 and Analog Output 2. Pressing the **Variable** button will open a list of available parameters for the user to choose from (Figure 2.19). The **Low Value** and **High Value** buttons permit the input range to be defined, regardless of the variable selected. Pressing these buttons will open the touchscreen keyboard and enable modification as necessary.

The **Out FS mV** button allows the output range of the associated DAC to be set. The 18-bit DAC's have a specified output of 0-4000mV. Although lowering this value will allow 100% of range High Value to be achieved at a lower output voltage, the total number of bits representing this value would be correspondingly reduced. In order to capitalize on all available 18-bits of resolution, and to satisfy the Signal Conditioner input requirement of 0-1 VDC, the circuitry incorporates a 4:1 voltage divider built into the SP-2000 signal processing detector board. Therefore, even though the **Out FS mV** is set to 4000mV, the resulting DAC analog voltage output is reduced to 1000mV at this setting.

The Out % FS Line will always indicate the current variable value relative to the variable range in percent full scale.

Section 2.2.7 Purge Override

The FGA-1000 has been certified for use in Class 1, Division 2 hazardous locations and purge pressure is necessary for maintaining certification requirements *(See Section 6).* The analyzer purge is intended to maintain positive pressure on the analyzer enclosures to prevent ingress of potentially hazardous atmospheres. Purge monitoring of the FGA-1000 is accomplished utilizing the Cyclops Z-purge device*.*

The purge override feature *(Figure 2.19)* is incorporated into the FGA software to permit analyzer operation without enclosure purge pressure. This enables the enclosure doors to be open for inspection or maintenance of the analyzer when the area is known to be non-hazardous. Access this mode by pressing **Settings > Purge Override**

Figure 2.19 – Purge Override Menu

The default time for Purge Override is 10 minutes. Pressing the **Start** button initiates the Purge Override function for the designated time. The time at the bottom of the menu reflects time remaining before the Purge Override function is disabled.

Should a different Purge Override time be desired, pressing the **Minutes** button will open an Enter Value window that allows the user change the Purge Override time up to 1,092 minutes, or just over 18 hours. Should more time than the originally entered time be necessary, the user may enter a new value at any time. Pressing the **Off** button will revert back to normal operation, but Purge Override should only be stopped after the enclosure doors have been closed and purge is reestablished to avoid shutdown of furnace and Run Cycles.

Section 2.2.8 System Settings

The System Settings menu allows the user to configure WARNINGS and ALARMS for the FGA-1000. To access this menu press **Settings > System Settings**

The System parameters are arranged in three groups. The upper group consists of seven digital inputs (DIs) that monitor status of critical and user-selected parameters. DI1 – DI3 are pre-assigned, while DI4 – DI7 are user-programmable. The pre-assigned parameters, DI1 – DI3 are considered system- critical conditions and are configured by default for ALARM. The DI4 – DI7 parameters are unassigned and can be utilized as a customer configurable digital inputs to either ALARM or WARN *(Figure 2.20).*

Figure 2.20 – System Settings Screen

The designated trip points for the system critical parameters are as follows:

Parameter	Trip Condition
(DI1) Loss of Purge	Enclosure Pressure Falls below 0.2" H_2O pressure
(DI2) O_2 Pressure - Stop	Zero Air Used for Combustion less than 20 PSIG
(DI3) Furnace Temp Low	Combustion Furnace Temperature less than 1025°C

The middle group monitors reported Zero, Span, and process values. These parameters allow the user to select both Low Alarm and High Alarm limit settings by entering the desired value in ppm after pressing the associated button. The most recent reported values are displayed between the High/Low limit settings for reference. These parameters are not system critical and can be programmed to WARN only. These are designed to provide indications of process/calibration upsets so that the upset can be tracked and corrective action taken. This would not be possible if the analyses were stopped in the event of a process upset.

The last group monitors the reported Temperature and Mass Flow controller values. These parameters also allow the user to select both Low Alarm and High Alarm limit settings by entering the desired value. The most recent reported values are displayed between the High/Low limit settings for reference. These parameters can be programmed to either WARN or ALARM.

> **NOTE:** The values used for alarm triggers in the Zero, Span and Process sections are averaged values. To modify the number of runs in the Zero and Span average, please refer to section 2.2.2, for the process average, please refer to section 2.3.3.

Alarm

If the ALARM status is enabled for any parameter, and that parameter falls out of its designated range, the FGA-1000 will trigger an alarm that will be indicated by a red LED in the State column *(Figure 2.21).*

Figure 2.21 – Loss of Purge Alarm

Any ALARM state will be reflected by the Analyzer Alarm Status line at the bottom of the System Control section of the Home Screen *(Figure 2.10)*. The message ALARM!, will also be prominently flash on the Main Menu bar in bold red text *(Figure 2.22)*.

Figure 2.22 – Main Menu Alarm

As soon as an ALARM state is triggered (except DI1 – DI3*), the analyzer is designed to immediately stop analyses. In addition, the GLOBAL ALARM relay will be activated. Run Cycles will automatically resume as soon as all alarm conditions are cleared and after any programmed Purge time has elapsed. This also means that all alarm conditions must be clear before any Run Cycles can be started.

__NOTE:__ DI1 (Loss of Purge), DI2 (O2 Pressure - Stop) and DI3 (Furnace Temperature Low) are system critical parameters and cannot be disabled. In the event of any of these Alarm conditions, the analyses will stop immediately as well as the furnace will be turned OFF. The Analyzer will not begin analyses until ALL three of these alarms are cleared in addition to any other alarm conditions.

Warning

If the WARN status is enabled for any parameter and that parameter falls out of its designated range, the FGA-1000 will trigger a warning that will be indicated by a yellow LED in the State column. Similar to ALARM status, the Warning will be also be reflected by the Analyzer Warn Status in the System Control section of the Home Screen, as well prominently flash on the Main Menu bar *(Figure 2.23)*.

Figure 2.23 – Main Menu Warning

Any parameter enabled to generate a WARN status, should it fall outside the designated range, is not considered to be a critical parameter for system operation. It is primarily intended to alert the user to a condition that may require intervention. Run Cycles will not be stopped when a WARN condition exists.

NOTE: To disable the alarm or warning monitoring, uncheck the respective box until the parameter is to be monitored again.

Section 2.2.9 Timed Event Settings

The Timed Event Settings menu allows the user to configure all timing functions associated with the Run Cycle *(Figure 2.24).* To access this menu press **Settings > Timed Events.**
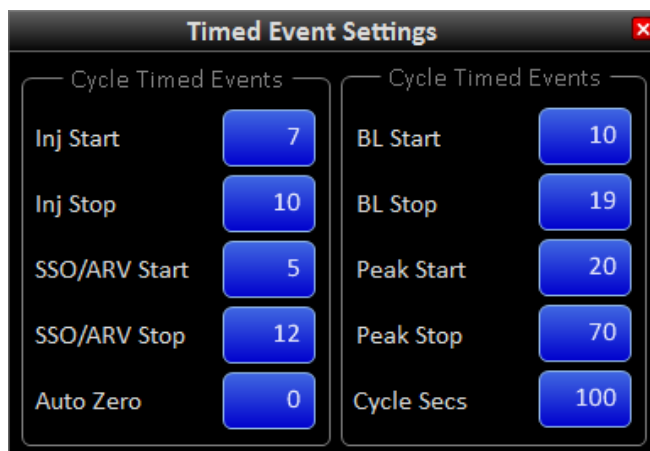

Figure 2.24 – Timed Event Settings Screen

The Timed Events Settings menu contains 6 separate Cycle Timed Events. These events are defined by 10 programmed timing entries that stipulate Run Cycle control and operation. Timed Events within this menu include:

Event Name	Description
Inj Start	Sample Valve is turned ON to Inject Sample in Loop
Inj Stop	Sample Valve is turned OFF to Reload Sample Loop
SSO/ARV Start	Sample Shut Off turned ON relieving Excess Pressure to Atmospheric Reference Vent
SSO/ARV Stop	Sample Shut Off turned OFF returning Normal Sample Flow through Inject Valve
Auto Zero	Sets Time when Auto Zero of Baseline is Performed (Setting of 0 = Off)
BL Start	Initiation of Baseline Evaluation Period; Values Averaged Establishing BL Value.
BL Stop	Completion of Baseline Evaluation; BL Average used to Correct Area Count Readings
Peak Start	Initiation of Peak Integration Period; Begin Summation of BL Corrected Readings
Peak Stop	Completion of Peak Integration Period; Sum All Data to Generate Peak Area Value
Cycle Secs	Sets Cycle duration and Defines completion of the Cycle Time.

To change the timing entry for any of these events, press the associated button that will open an Enter Value screen. The user enters the desired time in seconds and presses the **OK** button. Generally speaking, all settings provided in the Timed Events menu by the factory have already been optimized for best analyzer performance. Although the user is at liberty to make changes to these settings, analyzer performance cannot be guaranteed whenever factory settings have been modified from their original values.

NOTE: A value of zero (0) in the Timed Events Settings will turn off the event

Section 2.3 View

The View menu group contains submenus that provide information regarding instrument performance, but does not contain any settings related to instrument operation. *(Figure 2.25)*
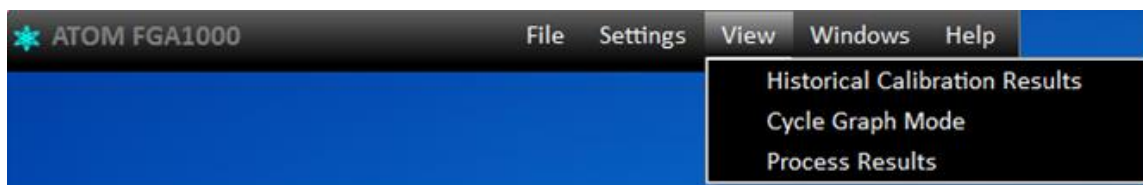

Figure 2.25 – View Dropdown Menu

Section 2.3.1 Historical Calibration Results

The Historical Calibration Results menu allows the user to review previous calibration results that were archived by pressing the **Calibrate and Save** button in the Calibration Settings menu. *(Figure 2.26).* To access this menu press **View > Historical Calibration Results.**

Figure 2.26 – Historical Calibration Results Screen

The menu is similar to the Check Calibration Results menu, but with supplemental information. The top line shows the date and time the displayed calibration information was saved. Pressing the down arrow located on the far right of the Date/Time Bar opens a list of all previously saved calibration results. The user can scroll through the list to select the desired calibration date, and then press OK to view the prior calibration results *(Figure 2.27).*

Figure 2.27 – Historical Calibration Results Dropdown Menu

The central section provides individual peak areas and concentrations, as well as the average of all completed cycles run. The Value Used section contains the final values selected for use. In other words, even though the analyzer computes the average area for Check Zero and Check Span concentrations in the Check Calibration process, the user may have used an alternate value for computing the "Calculated and Used" RF. User modification of these values will be evident if there is a difference between Average values and "Value Used".

Section 2.3.2 Cycle Graph Mode

The Cycle Graph menu is a graphical representation of the detector signal as it occurs in real time during the Run Cycle. This screen allows the user to ascertain general characteristics such as baseline noise, peak profile and peak integration period from one or more sequential analysis *(Figure 2.28).*

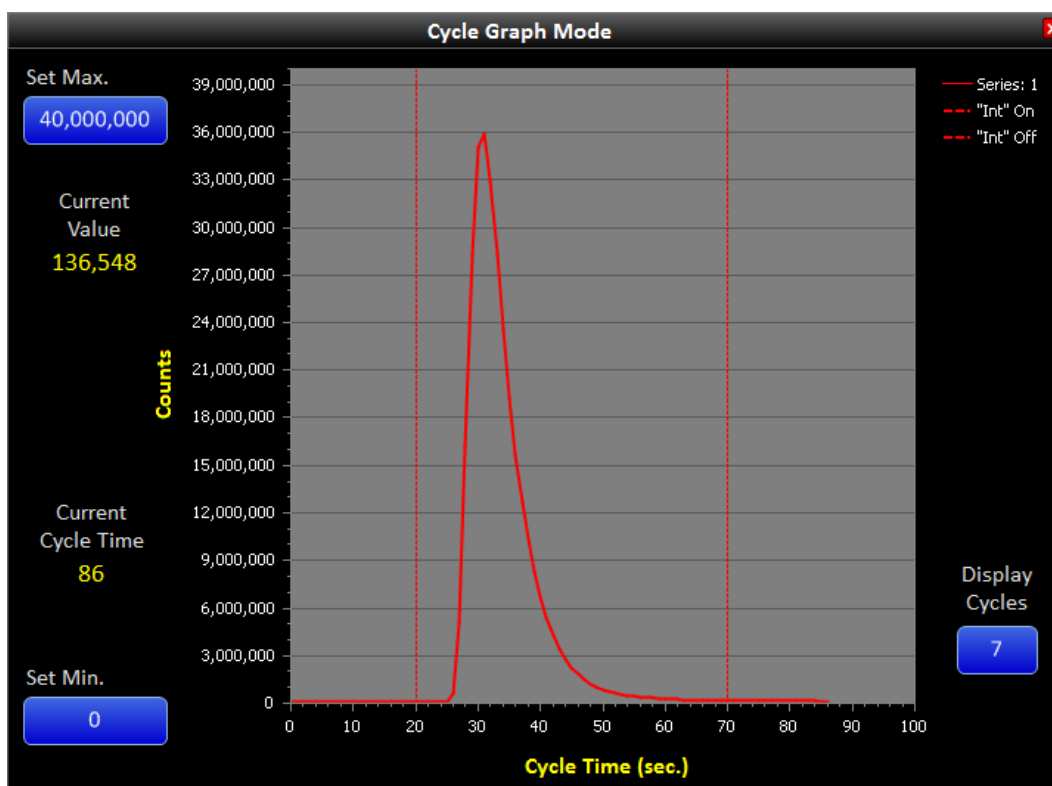To access the Cycle Graph Screen press, **View > Cycle Graph Mode.**

Figure 2.28 – Cycle Graph Mode Screen

<u>Cycle Graph</u>

The Cycle Graph is a typical X-Y graphical display plotting detector counts versus time in seconds. Individual data points are computed and plotted for each second of the programmed cycle time.

The graph also displays the Start and Stop time of the Peak Integration Window as denoted by the two vertical red lines. The software is designed to sum all baseline corrected areas within this window, or between 20 and 70 seconds in this example.

A feature only available when one series is selected for plotting in Display Cycles is a vertical line cursor with an associated text box. The user may press anywhere within the plot area to activate this cursor, causing an X-Y text box to appear. The user may move the cursor anywhere along the signal to display the time-counts values of the nearest data point. The text box will not appear until there is recorded data within the current Run Cycle *(Figure 2.29).*
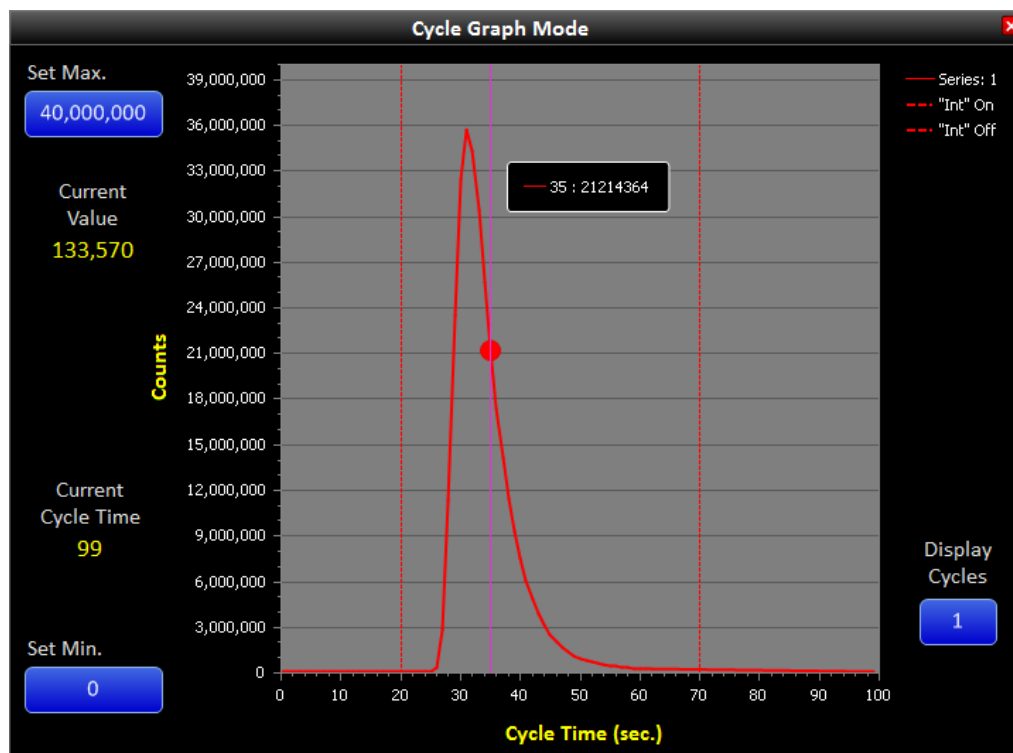

Figure 2.29 – Viewing Specific Data Points on Cycle Graph

Set Min and Set Max

These buttons allow the user to change the minimum and maximum scaling of the Cycle Graph. The scaling feature enables significant flexibility of the displayed data, depending on user preference.

Display Cycles

This button allows the number of cycles to be displayed as series, allowing graphical comparison of previous Run Cycles. Any number of sequential analyses may be chosen which are represented as Series 1-7 on the right side of the Cycle Graph.

The Series colors have been selected to convey temporal information related to the Run Cycle in the order in which the analyses occurred. The series colors are as follows:

Series 1	Red	
Series 2	Orange	
Series 3	Yellow	
Series 4	Green	
Series 5	Light Blue	
Series 6	Dark Blue	
Series 7	Purple	

The most recent series will always be red. As additional cycles are run, the color for the displayed series are scrolled such that the data represented by a particular color is always shifted to the next Series color at the beginning of a new cycle *(Figure 2.30)*.
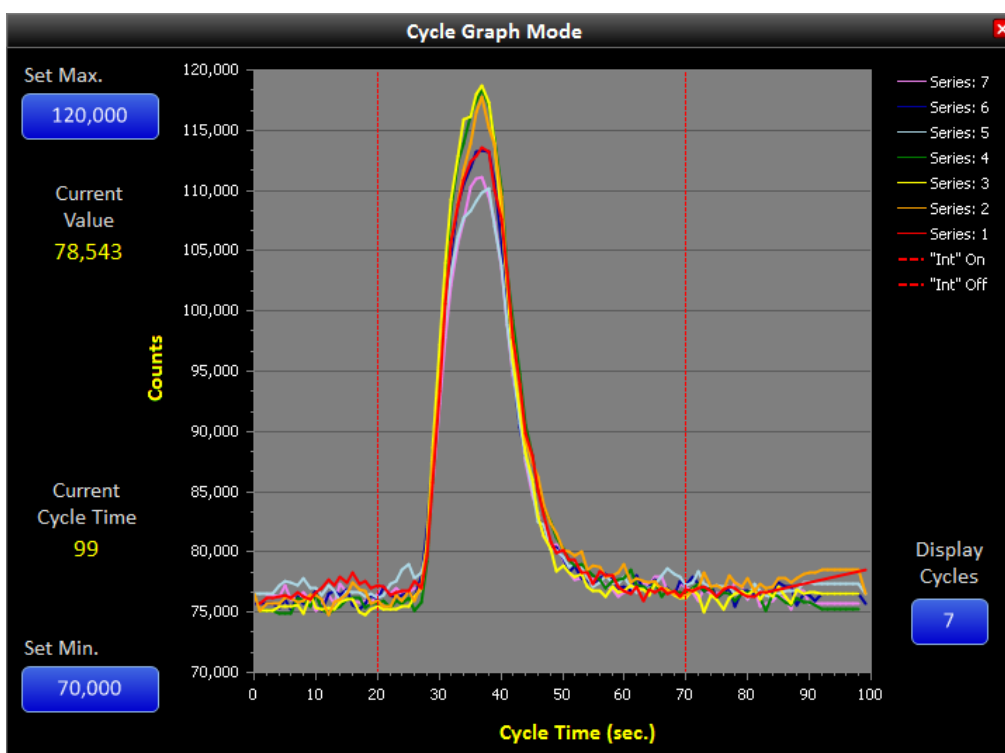

Figure 2.30 – Cycle Graph Displaying Multiple Trace Concentration Peaks

NOTE: If there is more than one series selected to be graphed, the previously described vertical cursor displaying the time and detector counts is disabled.

Current Value

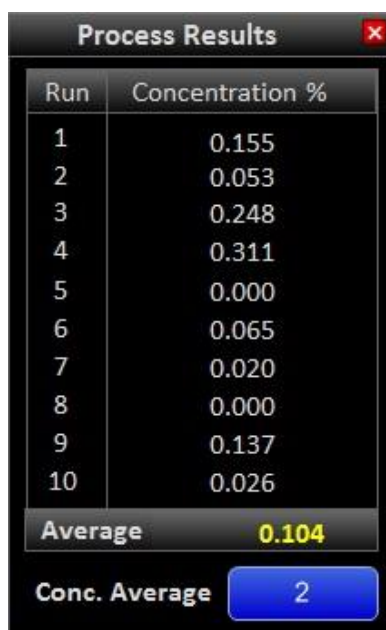This shows the current value as it rises and falls throughout the cycle period.

Current Cycle Time

> This is the same number that is displayed on the Home Screen and shows the current cycle time for convenience.

Section 2.3.3 Process Results

The Process Results menu screen allows the user to view analysis results in percent concentration of completed process samples run *(Figure 2.31).*

Open this screen by pressing **View > Process Results.**

Figure 2.31 – Process Results Screen

The Process Results menu screen displays a list of the last 10 samples run. The most recent sample is listed at the top and results will scroll down as subsequent samples are run.

The average concentration is displayed at the bottom of the table and includes the selected number of most recent runs. To select the number of runs included in the average, press the button adjacent to "Conc. Average" to open a select text box.

NOTE: If concentration is chosen as an output of the analyzer, the average concentration calculated above is outputted. To output the concentration for each single run (as displayed on the home screen), select a Conc. Average of 1.

Section 2.4 Windows

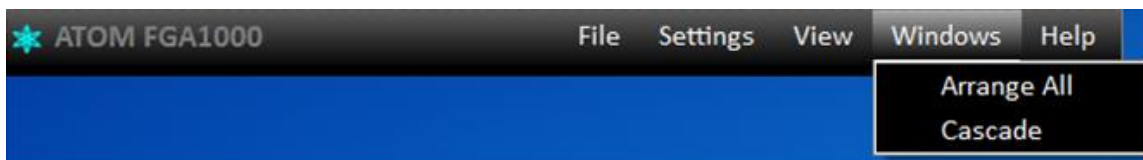The Windows menu screens allow the user to organize any open menus.

Figure 2.32 – Windows Dropdown Menu

Due to the relatively large size of the available menus in relation to the size of the FGA-1000 touchscreen computer display, the only practical arrangement option is to cascade open windows. The **Cascade** function stacks menu screens utilizing the title bar for reference in the order they were opened. Selecting either **Arrange All** or **Cascade** options generates identical arrangement of menu screens, such as in the example below. *(Figure 2.33)*
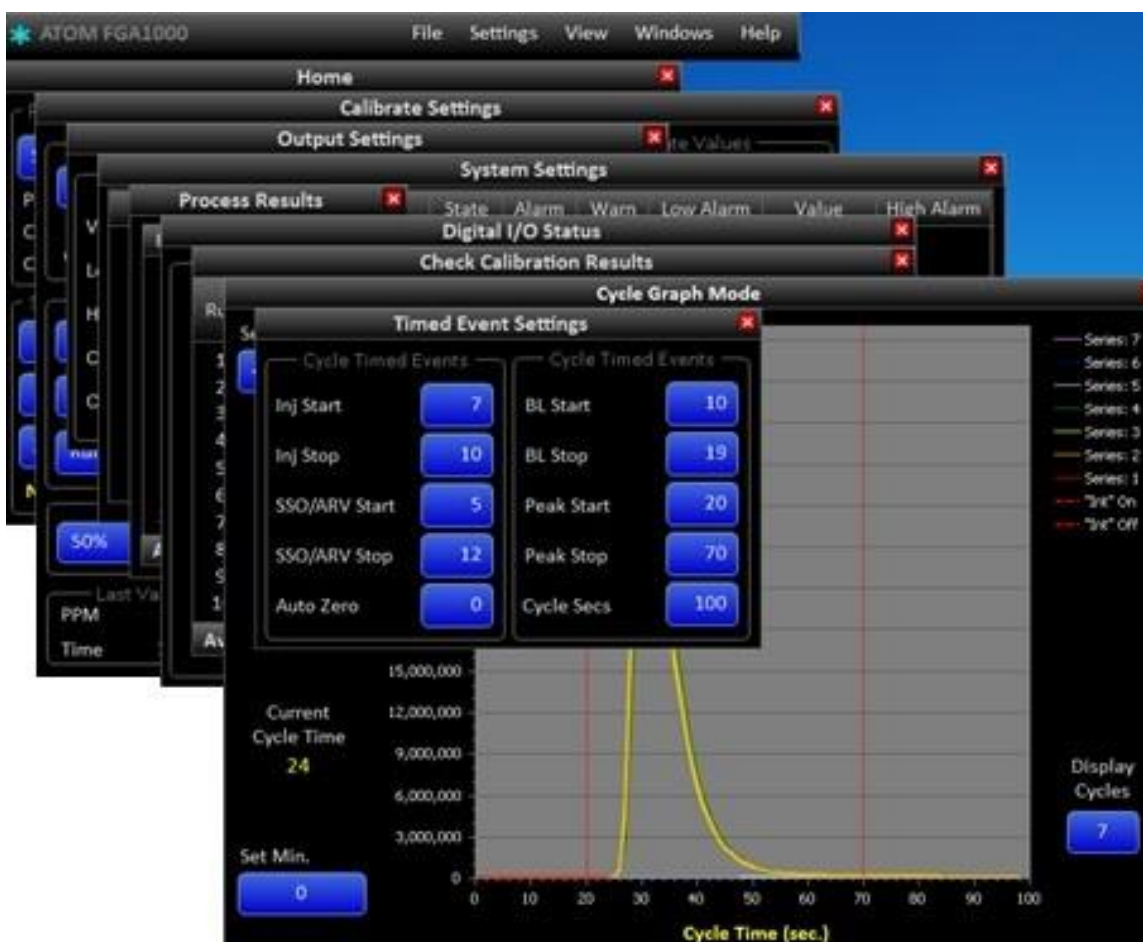

Figure 2.33 – Cascaded Menus

Section 2.5 Help

The **Help** section contains a single drop down selection menu *(See Figure 2.34).*

Figure 2.34 – Help Dropdown Menu

To access the **About Us** menu press **Help > About Us** *(See Figure 2.35).*

Figure 2.35 – About Us Screen

The **About Us** Menu Screen displays information regarding the software version and associated release dates of three separate programs. The GUI, Detector and Scanner programs have distinct functions, but work in conjunction with each other to provide comprehensive control of the FGA-1000 instrument and user interface.

Section 3 – Basic Maintenance Guide

Section 3.1 Combustion Tube Replacement

Begin by loosening the two screws indicated above inside the furnace chamber

Gently swing the furnace outward. The furnace incorporates a special roller bearing for support and allows near effortless movement.

Loosen and detach combustion tube inlet and outlet fittings
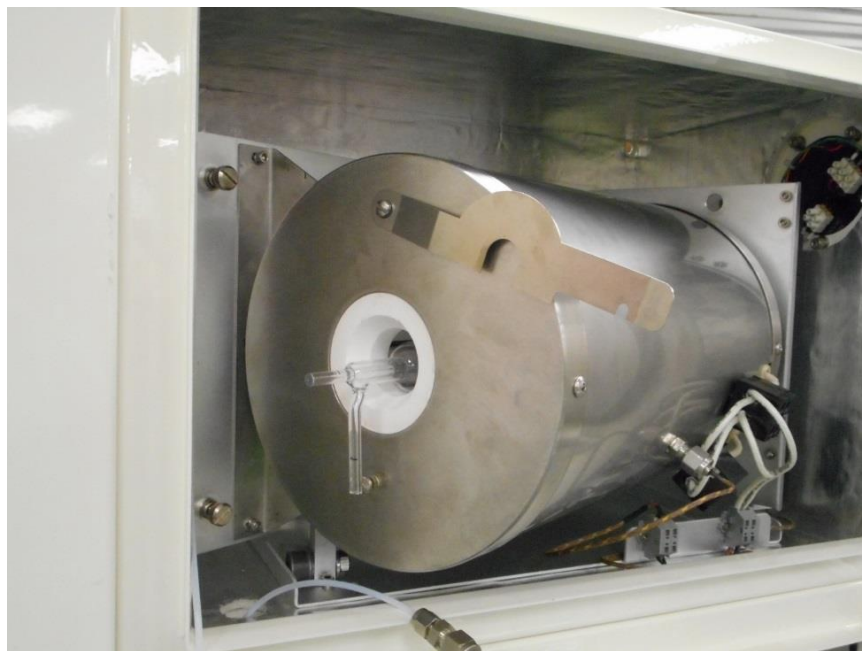
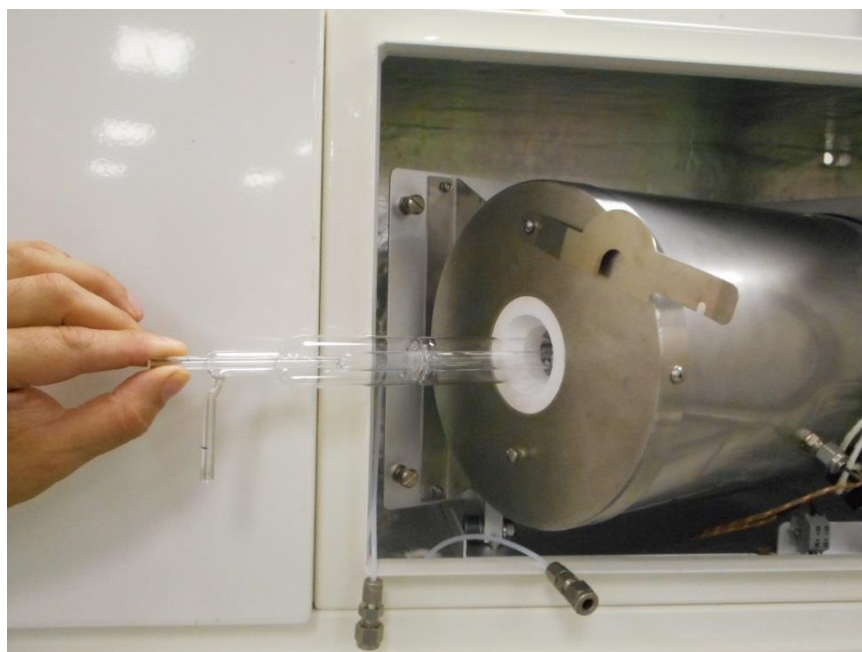

Fittings shown detached from combustion tube

Press and rotate the insulator clamp to allow access to the ceramic insulators

Carefully remove both ceramic insulators

The combustion tube is now ready to be removed

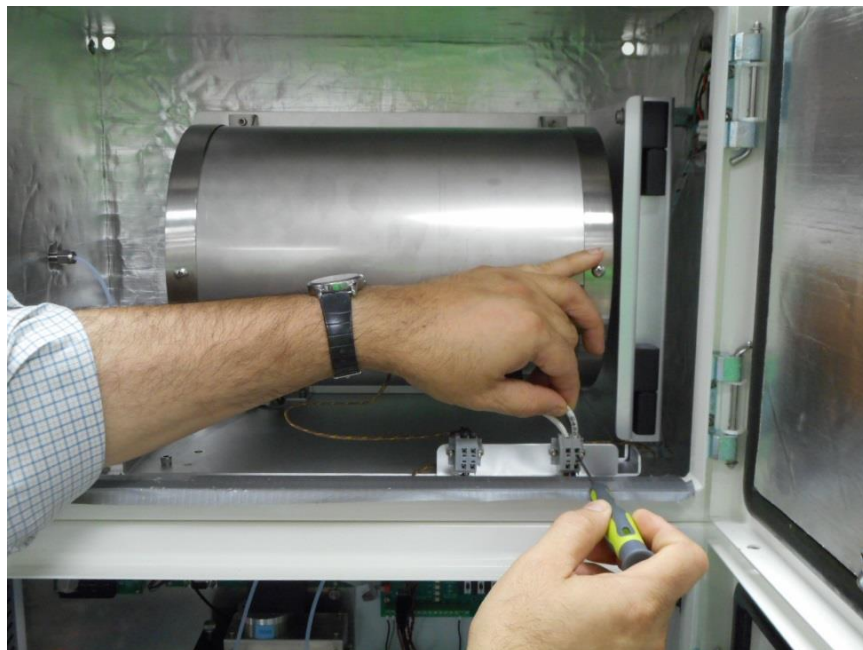Carefully and slowly remove the combustion tube from the furnace

Insert a new combustion tube, replace ceramic insulators, rotate and secure insulator clamp.

Re-attach combustion tube fittings, carefully roll furnace back in place and retighten screws.
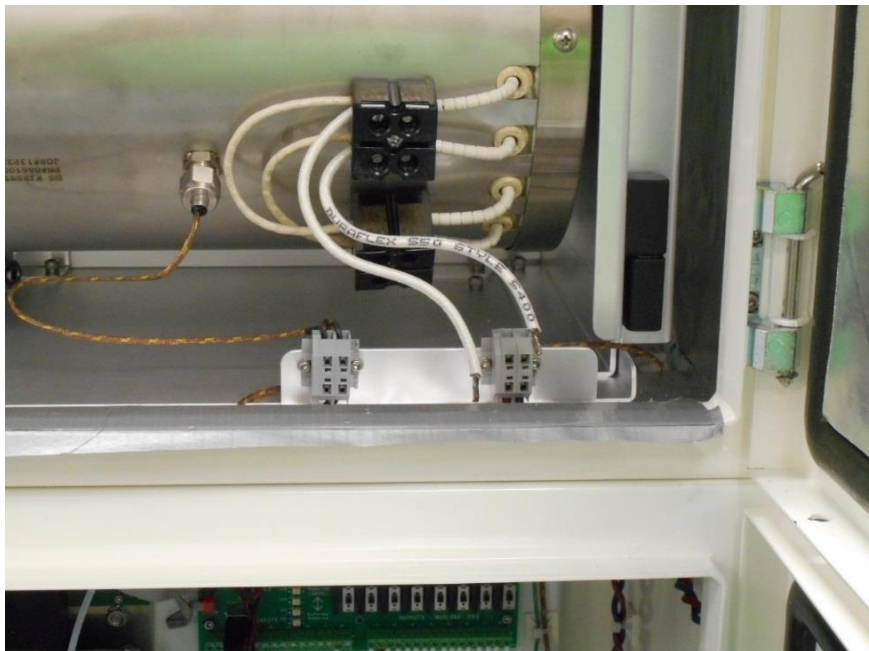
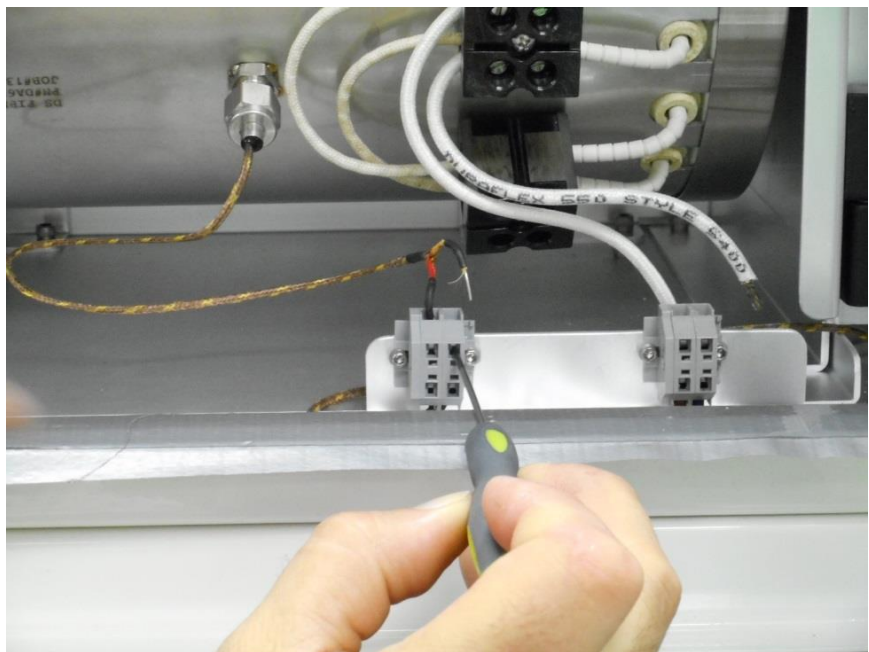## Section 3.2 Furnace Replacement
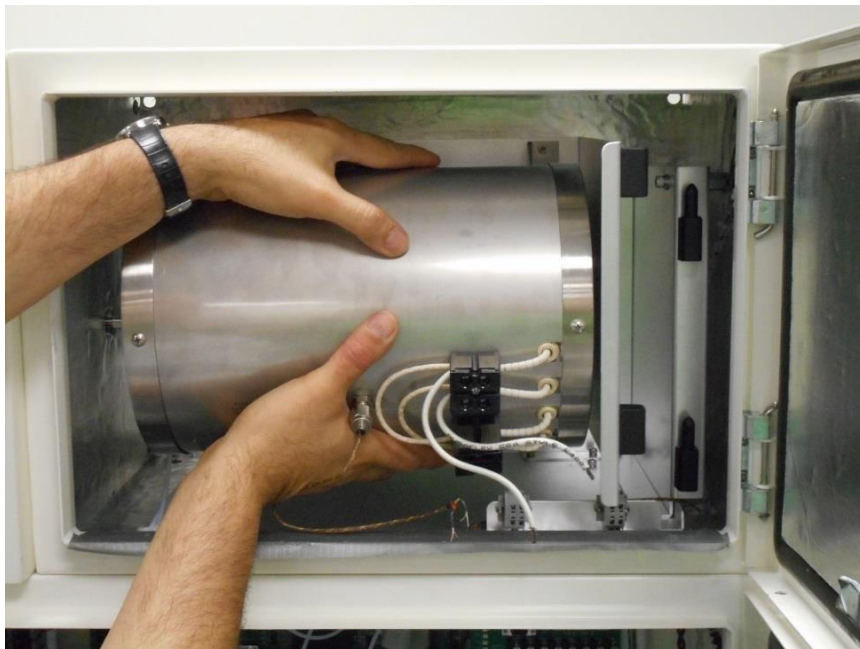

Begin by loosening both screws indicated above

Using a small screwdriver to compress the terminal spring, remove both heater wires

Heater wires removed from terminals

Repeat the above and remove both thermocouple wires from the terminals

Carefully lift the furnace up off of the pin hinges and remove from the furnace chamber
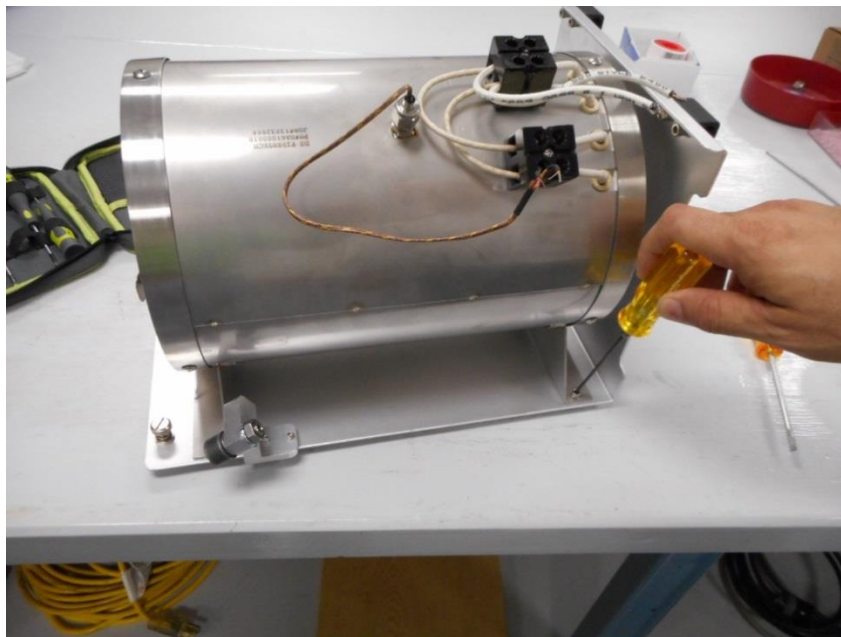
Remove all four furnace mount screws to complete the disassembly process. Follow the process in reverse order to install a new furnace and re-wire it.

Section 3.2 Membrane Dryer Replacement
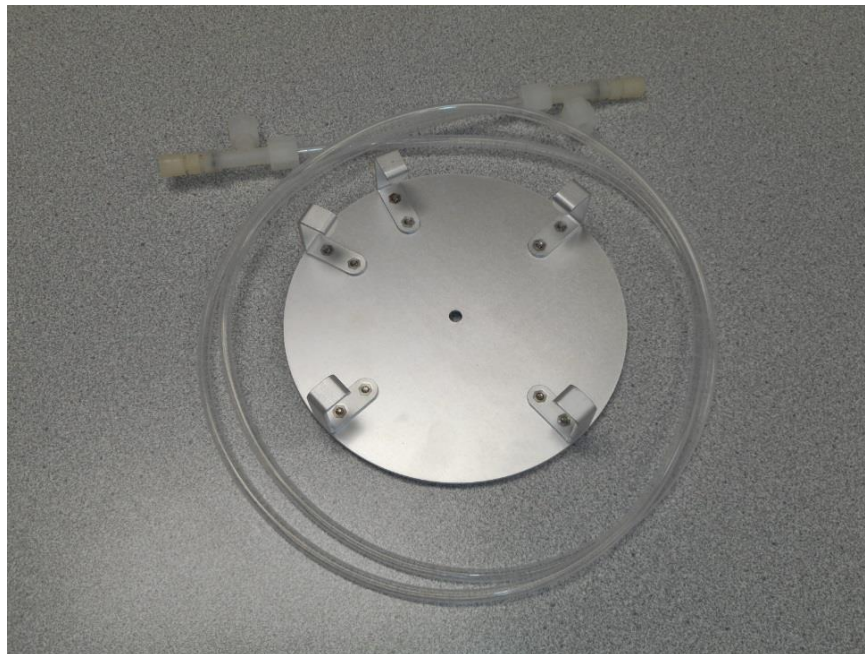
Orient the permeation tube fitting as shown
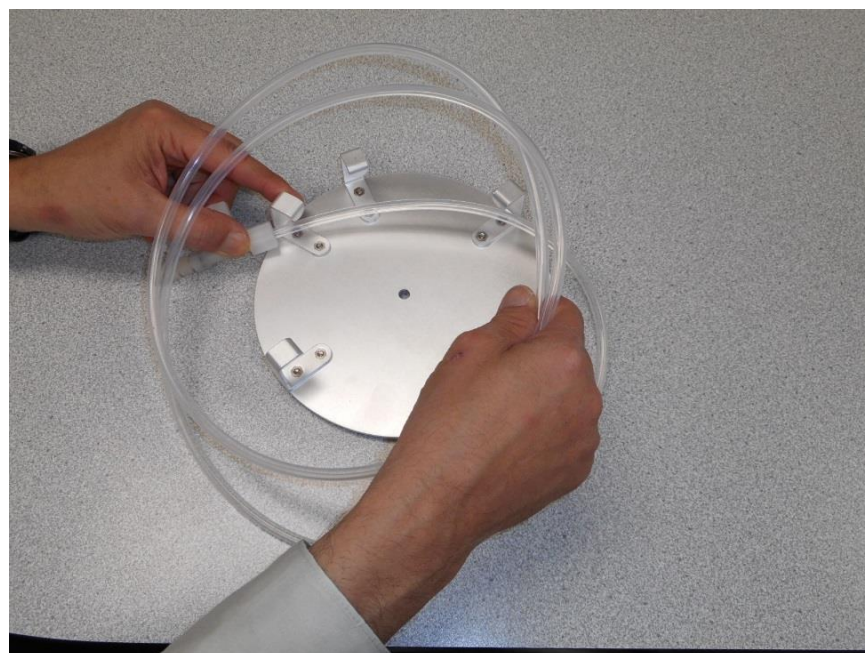
Begin by placing the tubing inside of the mounting bracket
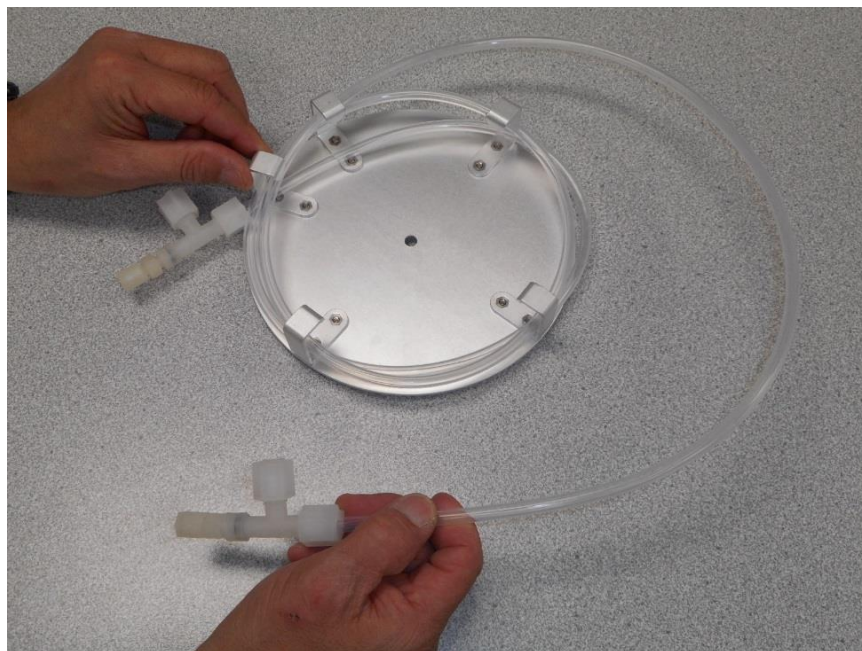
Continue winding, stacking the dryer layer upon layer

Until dryer has been completely wound
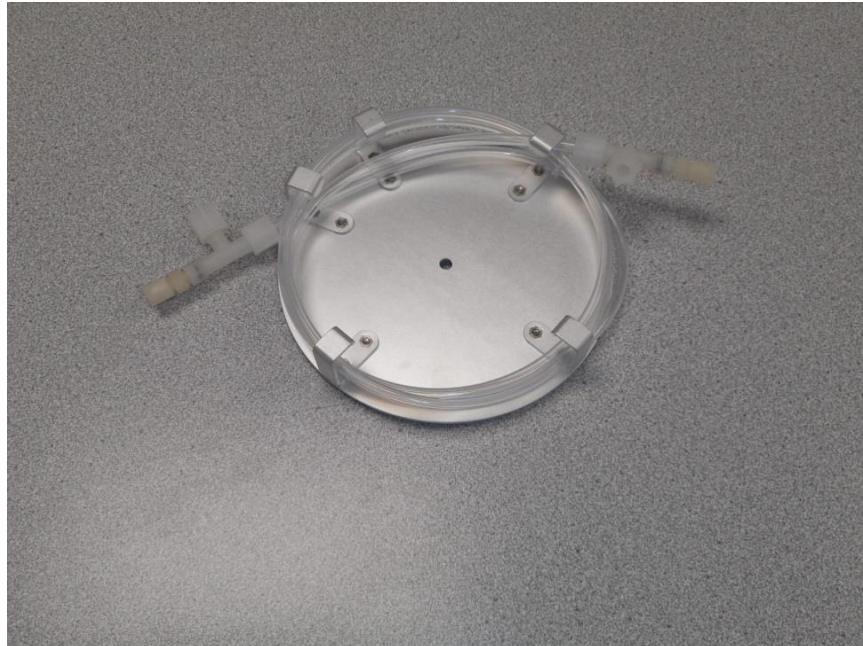
After winding, the Perma Pure Dryer should look like this

Next, lift tubing to push the first fitting back inside
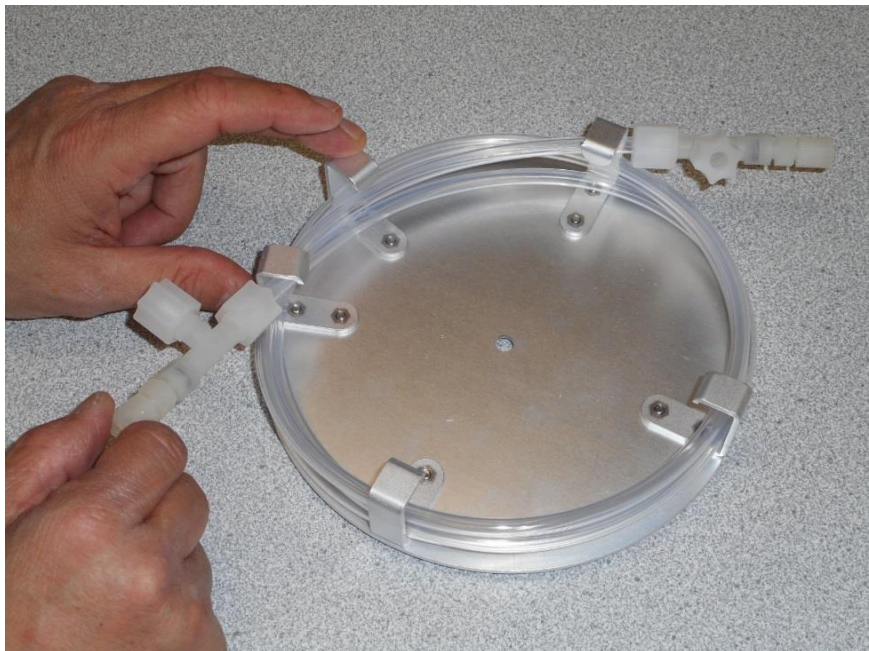
Then bring to the top against the mounting bracket
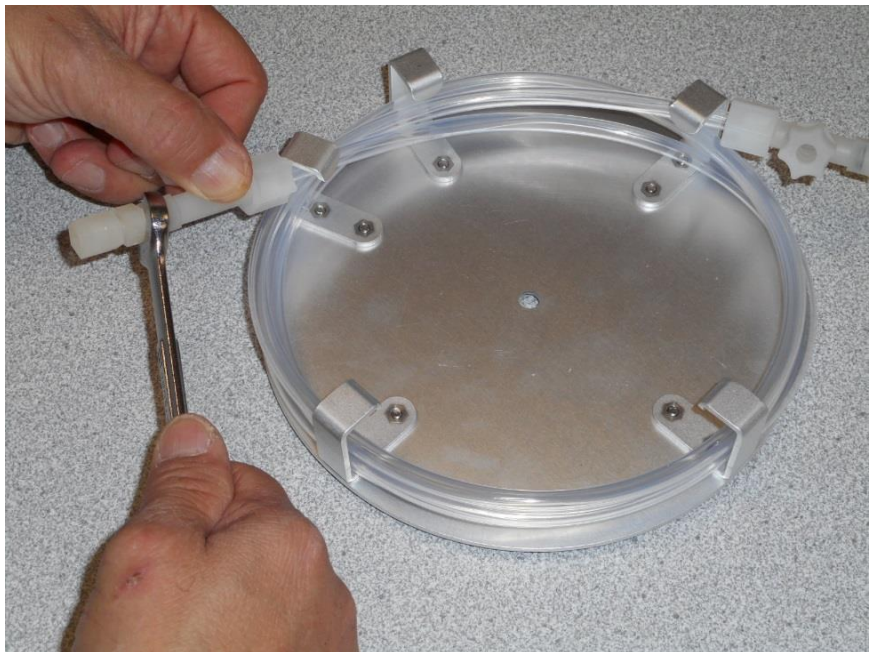
Using a 7/16" wrench, loosen and remove the 1/8" fittings on both ends
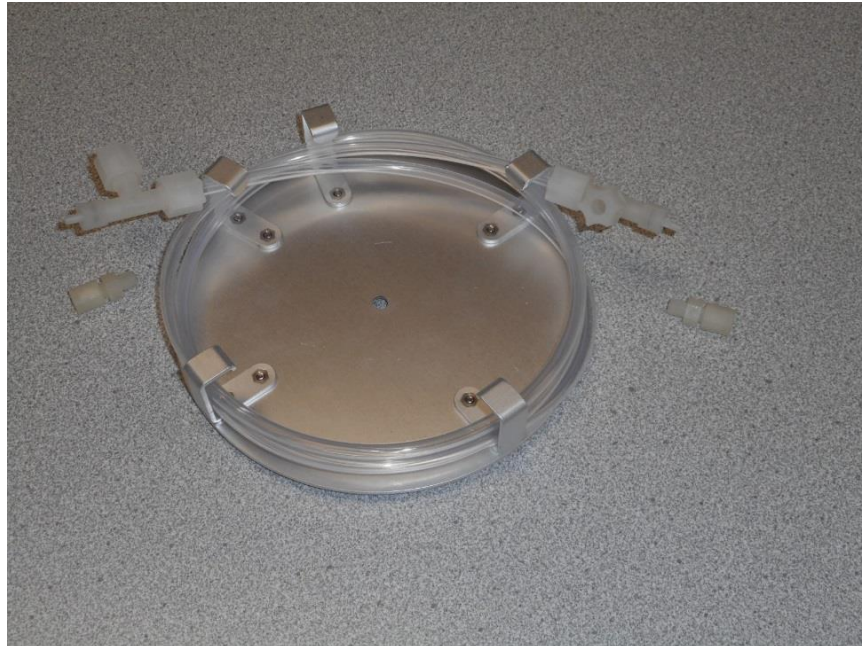
The dryer should look like this after both end fittings are removed

Next, loosen but <u>do not remove</u> the ¼" inch fitting on both ends
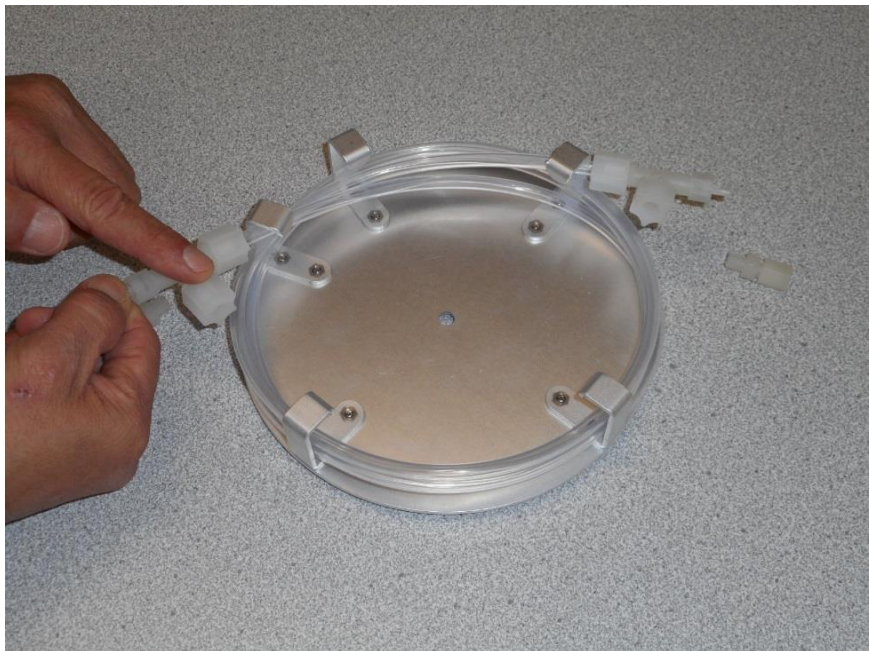
Holding the inner tube, rotate the T-fitting to point toward the inside on both ends
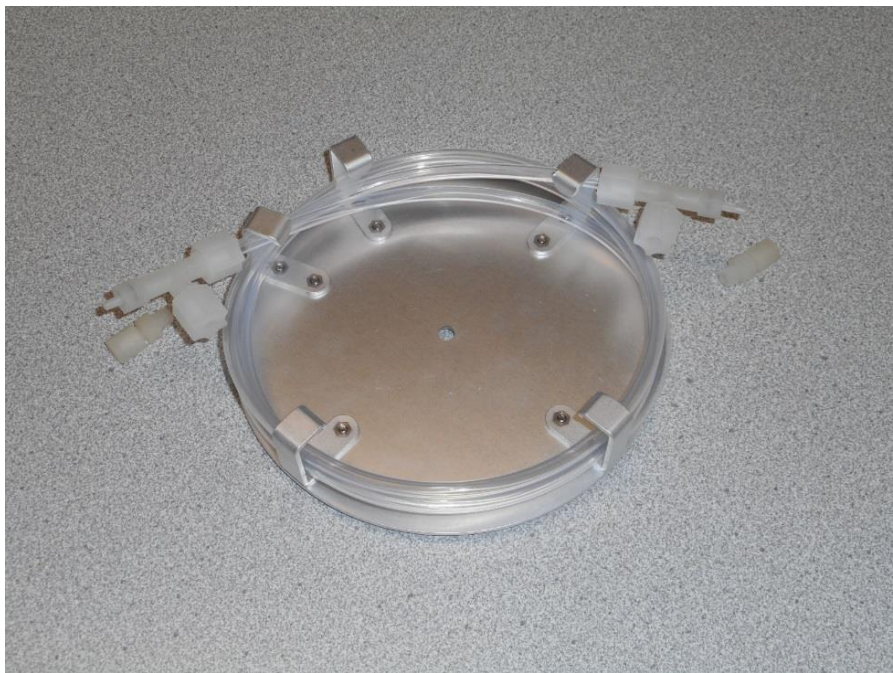
The dryer should then look like this
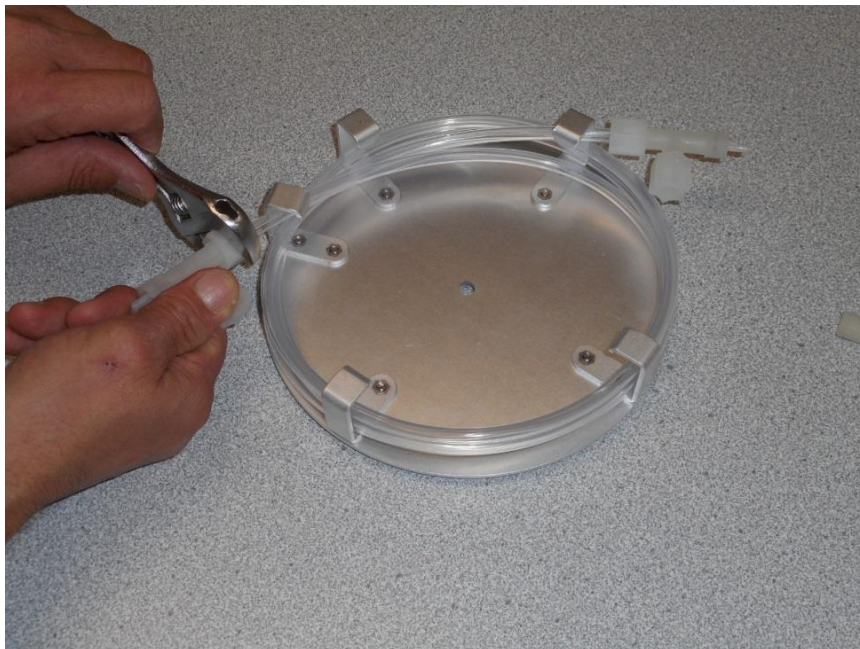
Re-tighten both ¼"T-fittings
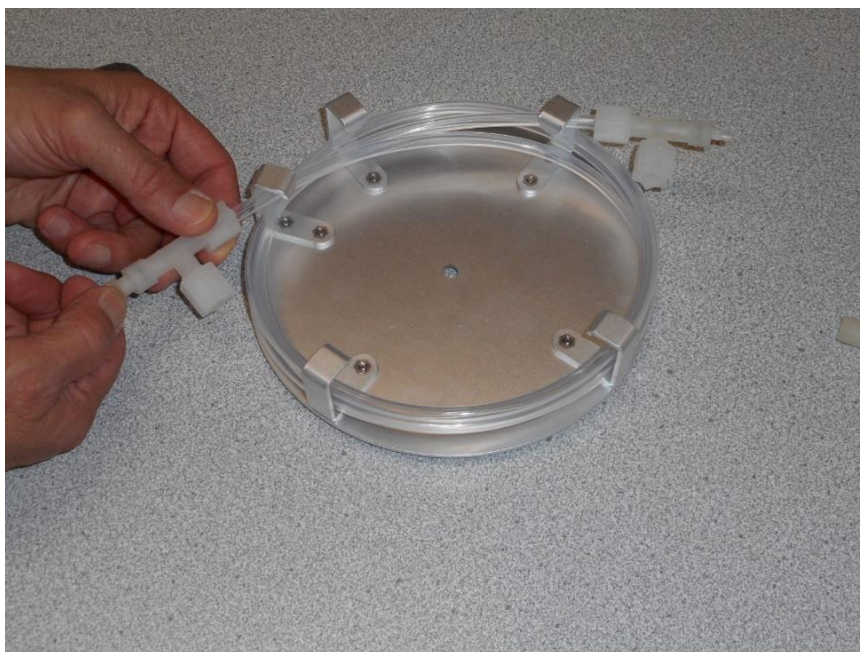
Lastly, re-attach both 1/8" inch end fittings

The Membrane dryer is now ready to be reinstalled on the analyzer.

Section 3.3 Shinko Temperature Controllers

The FGA-1000 has three separate temperature zones controlled by Shinko Model DCL-33A temperature controllers, which include the Sample Enclosure, Combustion Furnace and Main Enclosure. These DIN rail mounted controllers are approximately located in the center of the Main Enclosure, and are underneath the right-hand side of the detector module. *(Figure 3.1)*
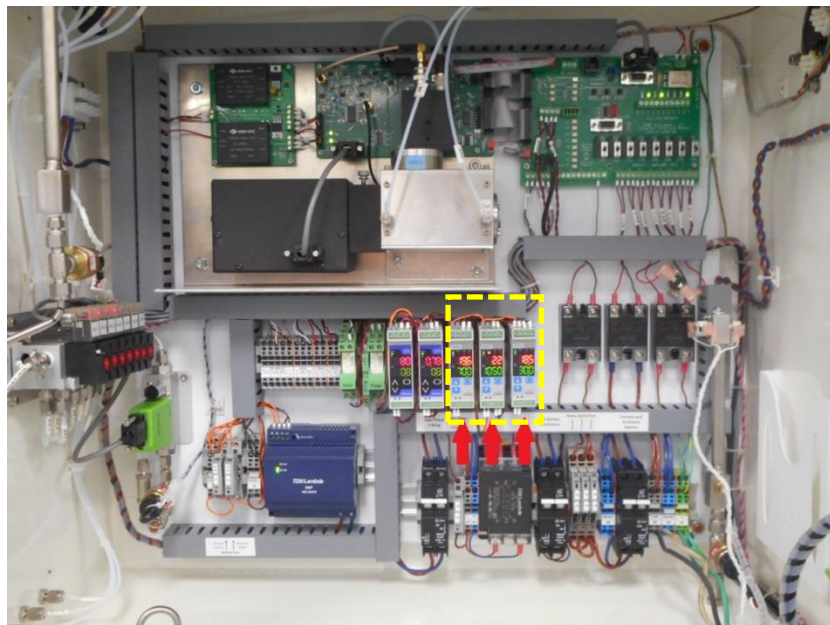
Figure 3.1 – Shinko Temperature Controllers

Factory recommended temperature set-points are as follows:

1. Sample Enclosure: 70°C (or sufficient to prevent any condensation of sample)
2. Combustion Furnace: 1050°C (minimum for complete sample combustion and Sulfur conversion)
3. Main Enclosure: 30°C (may be increased to 40°C if necessary in colder environments)

The temperature controller settings have been programmed into the instrument installed controllers at the factory and are included in this manual for reference purposes only. The following page contains factory settings for the three Model DCL-33A Temperature Controllers for the FGA-1000. *(Section 3.3.1)*

For complete instructions and menu navigation for the parameters below, refer to the Shinko DCL-33A Indicating Controller Instruction Manual.

Note: Although autotuning is a routine function which is part of analyzer testing at the factory, it is recommended that subsequent autotuning of these controllers is performed in the field for best results.

Section 3.3.1 Shinko Temperature Controller Programmed Settings

Step	7-Segment Display	Parameter Function	Sample Enclosure Heater	Combustion Furnace Heater	Main Enclosure Heater
		Main setting mode			
1	5	Desired value	70.0	1050	30.0

Press [○] to change Desired Value

Step	7-Segment Display	Parameter Function	Sample Enclosure Heater	Combustion Furnace Heater	Main Enclosure Heater
		Sub setting mode			
1	AT	Auto tuning perform/cancel	AT	AT	AT
2	P	OUT proportional band	Auto calc	Auto calc	Auto calc
3	I	Intergral time	Auto calc	Auto calc	Auto calc
4	d	Derivative time	Auto calc	Auto calc	Auto calc
5	n	Anti-reset windup	Auto calc	Auto calc	Auto calc
6	c	OUT proportional cycle	Auto calc	Auto calc	Auto calc
7	rSET	Manual reset	Skip	Skip	Skip
8	A1	Alarm value	Skip	25	Skip
9	H	Heater burnout alarm valve	Skip	Skip	Skip
10	LP_r	Loop break alarm time	0	0	0
11	LP_H	Loop break alarm span	0.00	0	0.00

Press the [○] key while holding down the [△] key. Press the [○] key to navigate to the next menu item.

Step	7-Segment Display	Parameter Function	Sample Enclosure Heater	Combustion Furnace Heater	Main Enclosure Heater
		Auxillary function setting mode 1			
1	Lock	Set value lock	- - - -	- - - -	- - - -
2	5o	Sensor correction	0.0	0.0	0.0
3	cn5L	Communication protocol	nodr	nodr	nodr
4	cnno	Instrument number	1	2	3
5	cn5P	Communication speed	192	192	192
6	cnPr	Parity	nonE	nonE	nonE
7	cn5r	Stop bit	1	1	1

Press the [○] key for approx. 3 sec while holding down the [▽] key. Press the [○] key to navigate to the next menu item.

Step	7-Segment Display	Parameter Function	Sample Enclosure Heater	Combustion Furnace Heater	Main Enclosure Heater
		Auxillary function setting mode 2			
1	5En5	Input type	t C	5 C	t C
2	5rLH	Scaling high limit	80.0	1100	40.0
3	5rLL	scaling low limit	60.0	1000	20.0
4	dP	Decimal point place	Skip	Skip	Skip
5	FILr	PV filter time constant	0.0	0.0	0.0
6	oLH	OUT high limit	100	100	100
7	oLL	OUT low limit	0	0	0
8	HY5	OUT ON/OFF hysteresis	Skip	Skip	Skip
9	AL1F	Alarm type	- - - -	HL	- - - -
10	A1Ln	Alarm action Energized/De-energigized	Skip	nonL	Skip
11	AHLd	Alarm HOLD function	Skip	nonE	Skip
12	A1HY	Alarm hysteresis	Skip	5.0	Skip
13	A1dY	Alarm action delay timer	Skip	0	Skip
14	conr	Direct/Reverse control	HEAr	HEAr	HEAr
15	Ar_b	AT bias	20.0	20	20.0
16	5U_b	SVTC bias	0.0	0	0.0
17	FUnc	Output status when input abnormal	Skip	Skip	Skip
18	EoUr	Controller/Converter	Skip	Skip	Skip

Press the [○] key for approx. 3 sec while holding down the [▢] key. Press the [○] key to navigate to the next menu item.

Section 3.4 Shinko Signal Conditioners

The FGA-1000 has two analog outputs that utilize Shinko, Model SAU-1 DIN rail mounted Signal Conditioners. These modules have been configured to deliver a 4-20mA output, with a 0-1VDC input signal. These controllers are located in the center of the Main Enclosure, to the left of the three temperature controllers. *(Figure 3.2)*

The intended analyzer variable for the controller input is selected from the Output Settings of the FGA analyzer software utilizing the computer touchscreen. The variable can then be ranged within the same menu as desired, which will deliver the 0-1VDC signal from the SP-2000 Signal Processing Detector board DAC to the Shinko Signal Conditioner input. *(Section 3.4.1)*
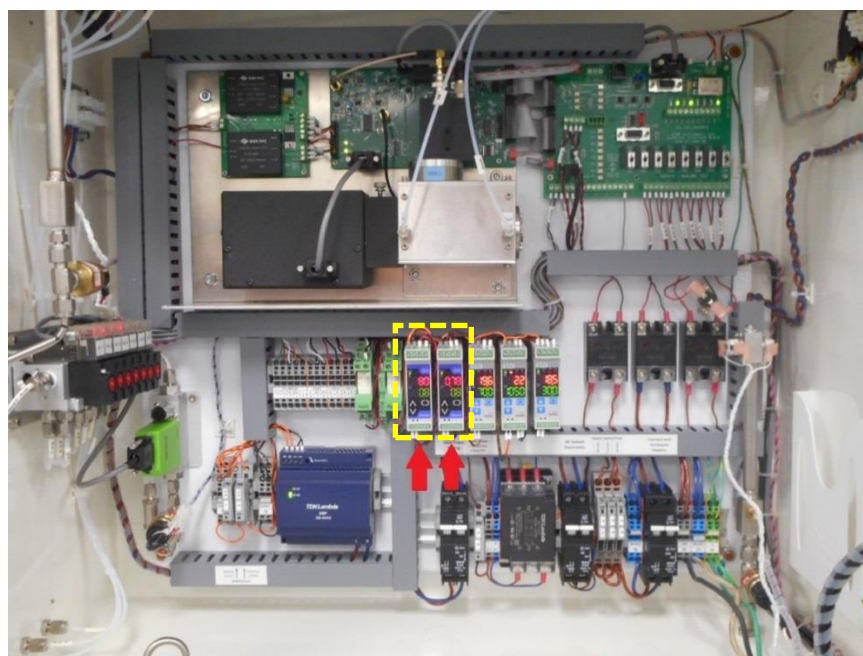
Figure 3.2 – Shinko Signal Conditioners

The two Signal Conditioning Modules have been programmed by the factory for the following:

	Input	**Output**	**Reading**
Channel A:	0-1VDC	4-20mA	0-9999 (ppm when Conc. is the variable, ranged 0-1%)
Channel B:	0-1VDC	4-20mA	0-50.00 (% when Conc. is the variable, ranged 0-50%)

Section 3.4.1 Shinko Signal Conditioner Programmed Settings

Step	7-Segment Display	Parameter Function	Ch A (4-20 mA)	Ch B (4-20 mA)
Adjustment mode				
1	o̅Ξr1	Output zero	0.00	0.00
2	oЧP1	Output span	0.00	0.00
3	o̅Ξr2	Output 2 zero	Skip	Skip
4	oЧP2	Output 2 span	Skip	Skip
5	1Ξ̅Er	Potentiometer zero input	Skip	Skip
6	1ЧPA	Potentiometer zero output	Skip	Skip
Setup mode				
1	Lock	Set value lock	- - - -	- - - -
2	ЧEnЧ	Input	dcᵁ	dcᵁ
3	dcᵁ	DC voltage input range	0□1ᵁ	0□1ᵁ
4	dP	Decimal point place	0.0	0.0
5	ЧrLL	Output 0% value	0.0	0.0
6	ЧrLH	Output 100% value	999.9	999.9
7	FiLr	Filter time constant	0.0	0.0
8	Чo	Sensor correction	0.0	0.0
9	oᵁrP	Output	420A	420A
10	oᵁrЧ	Output Normal/Reverse	noᴿL	noᴿL
11	bᵁrn	Burnout	Skip	Skip
12	di ЧP	Display	dUAL	dUAL
13	riᴿE	Indication time	00.00	00.00

Hold down the 🔵 key for approx. 3 sec. Press the 🔵 key to navigate to the next menu item. Hold down the 🔵 key for approx. 3 sec to exit the menu.

Press the 🔵 key for approx. 3 sec while holding down the ⬜ (blank) key. Press the 🔵 key to navigate to the next menu item.

Section 3.5 Updating Software

The FGA-1000 computer software and detector firmware are easily upgraded as revisions become available from the factory. The GUI and scanner software reside on the solid-state hard drive of the touchscreen computer. The detector firmware can be upgraded utilizing what is known as a bootloader program, which is accessible from the program icon located on the desktop. Future updates may include changes to any, or all embedded programs. Instructions for how to load and update the FGA-1000 software to include the latest released revisions are included below.

Section 3.5.1 Installing the GUI and Scanner software using the installer program

STEP 1: INITIAL SETUP

1. Stop the analysis/cycle (if running)

2. **Settings backup**: On the GUI program take screen-shots (or manually write down information) of the following screens. This can be used to manually re-enter the original settings in the event the data gets erased during software installation.

   Settings ⟶ Home
              ⟶ Calibrate Settings
              ⟶ Detector Settings
              ⟶ System Settings
              ⟶ Timed Events Settings
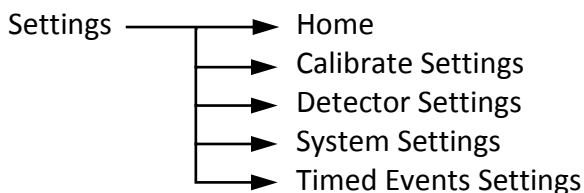
3. Close the GUI program (*Figure 3.3*).

Figure 3.3

4. Close the main Atom program (*Figure 3.4*).
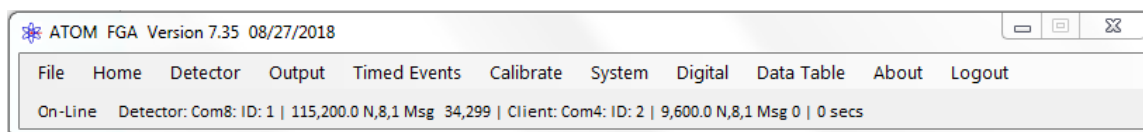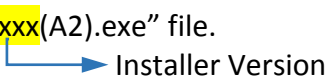
Figure 3.4

STEP 2: INSTALLING THE REDISTRIBUTABLES

1. Double-click on the "ATOM_FGA_Redist_Vxxx(A2).exe" file.
                                                    Installer Version

2. On the start screen that comes up, click on "Next" (*Figure 3.5*).
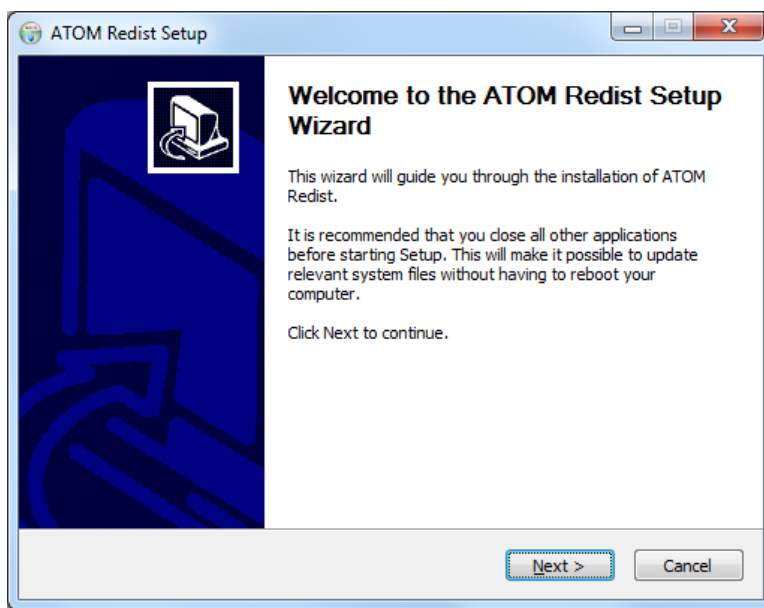
Figure 3.5

3. Leave all options "checked", and click **Install** (*Figure 3.6*).

Figure 3.6

190514 ATOM FGA Manual – Rev C FGA-1000 User's Manual

4. The installation process will begin (no user intervention is necessary) (*Figure 3.7*).

Figure 3.7

5. Once the installation is complete (~ 5 - 10 mins), and when prompted, click "Close" (*Figure 3.8*).

Figure 3.8

This completes the installation of the .NET framework and the SQL Server.
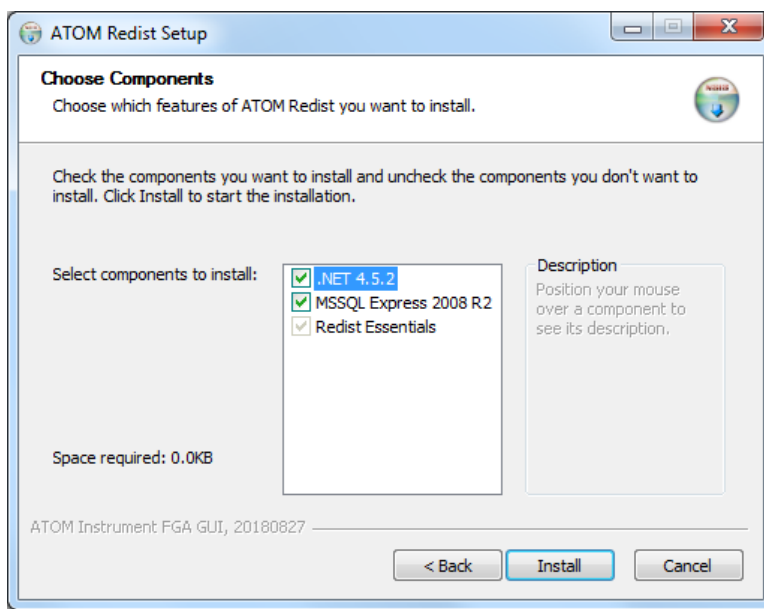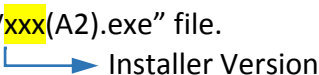
STEP 3: INSTALLING THE GUI

1. Double-click on the "ATOM_FGA_GUI_Vxxx(A2).exe" file.

    Installer Version

2. On the start screen that comes up, click **Next** (*Figure 3.9*)
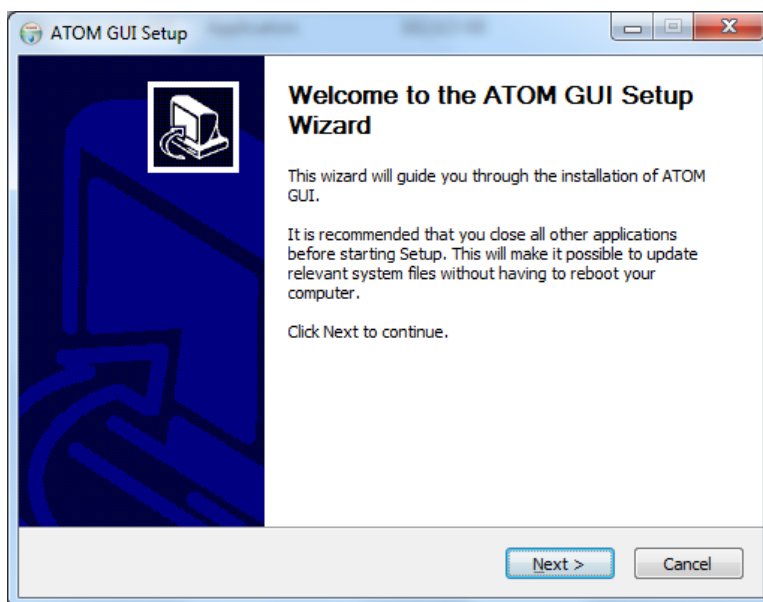
Figure 3.9

3. Leave all options "checked", and click **Install** (*Figure 3.10*)
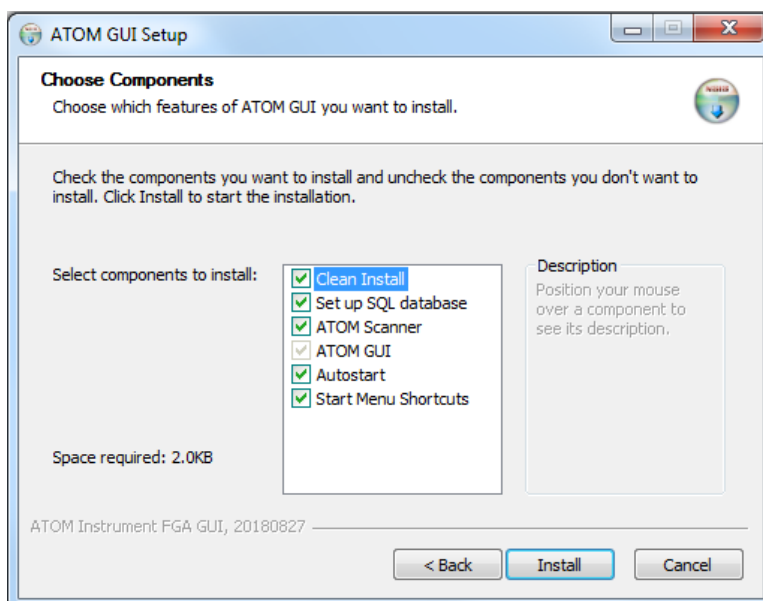
Figure 3.10

4. Once the installation is complete (~ 1 - 2 mins), click **Close** (*Figure 3.11*)
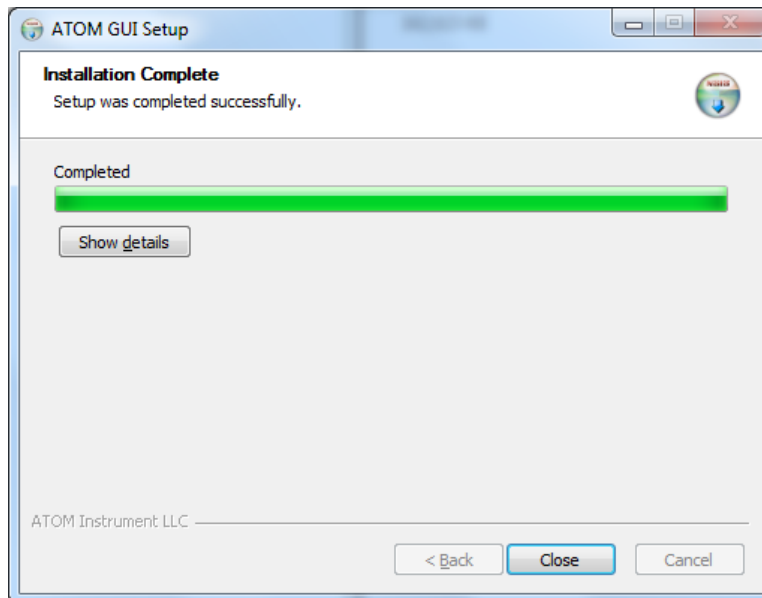
Figure 3.11

This procedure copies all the updated files into the "C:\ATOM!\" and "C:\ATOM_GUI\" directories.
The updated .HEX file, which needs to be loaded onto the Detector board, is also copied into the "C:\ATOM!\" directory.

The following section explains the procedure to load this .HEX file onto the Detector board.

Section 3.5.2 Bootloader Procedure for Detector Board

This procedure replaces the embedded HEX file firmware program in the SP-2000 Signal Processing detector board microprocessor. This file must be installed separately as it cannot load automatically without accessing and utilizing the Microchip bootloader program per the following instructions below. Before beginning this procedure, the user will either need the required HEX file to already be on the computer.

<u>Transferring the HEX file from C:\ATOM! to the SP-2000 board:</u>

1. Open the bootloader software by double-clicking on the "AN1310ui" shortcut on the PC Desktop (*Figure 3.12*).

Figure 3.12: Bootloader Icon

2. Press the green **Run Mode** button on the bootloader screen (*Figure 3.13*). At the bottom right hand side of the screen the "<u>**Connected**</u>" <u>status will appear as well as the **COM** Port number</u>.
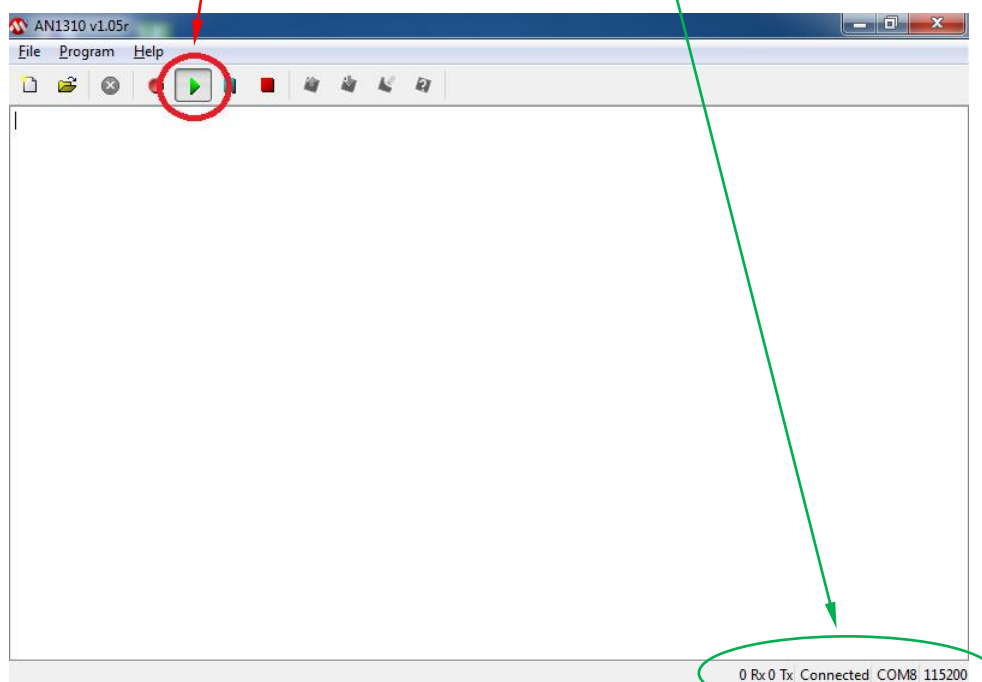
Figure 3.13

3. Press the blue **Break/Reset Mode** button (*Figure 3.14*). The bottom status bar will request resetting the SP-2000 board.
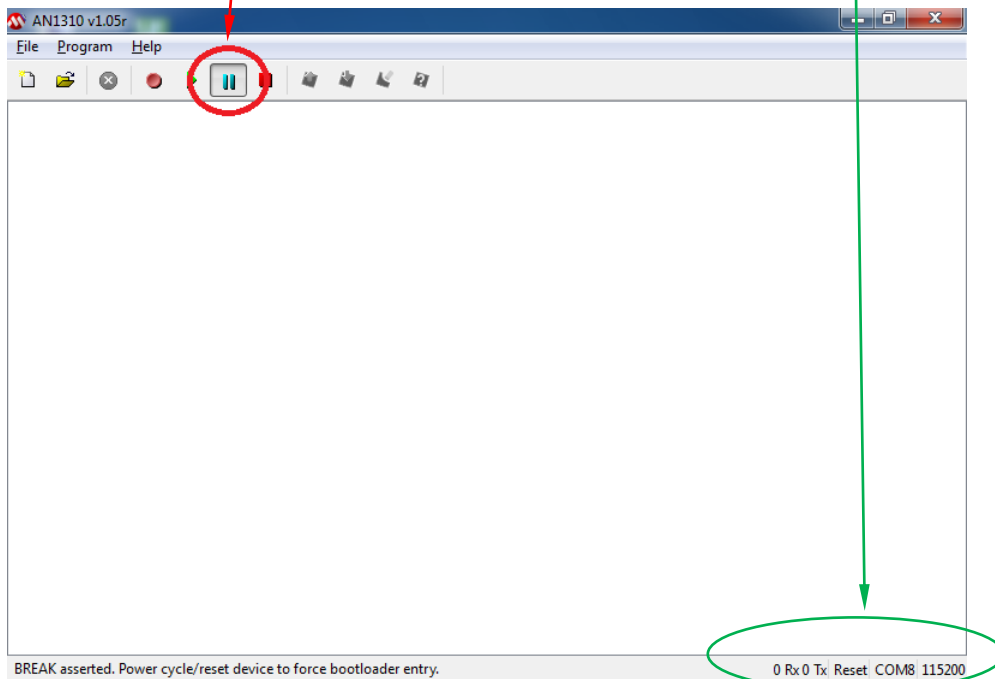
Figure 3.14

4. On the SP-2000 board inside the main analyzer enclosure (*Figure 3.15*), press and hold the Reset button for 2 seconds. The SP-2000 board is located immediately behind the Detector assembly.

⚡ ***IMPORTANT**......you only have 30 seconds to press the "Reset" button before the communication "Times Out". If the connection times out, close the program and re-start from beginning of **Step 1.***

Figure 3.15

5. Press the red **Break Mode** button (*Figure 3.16*).
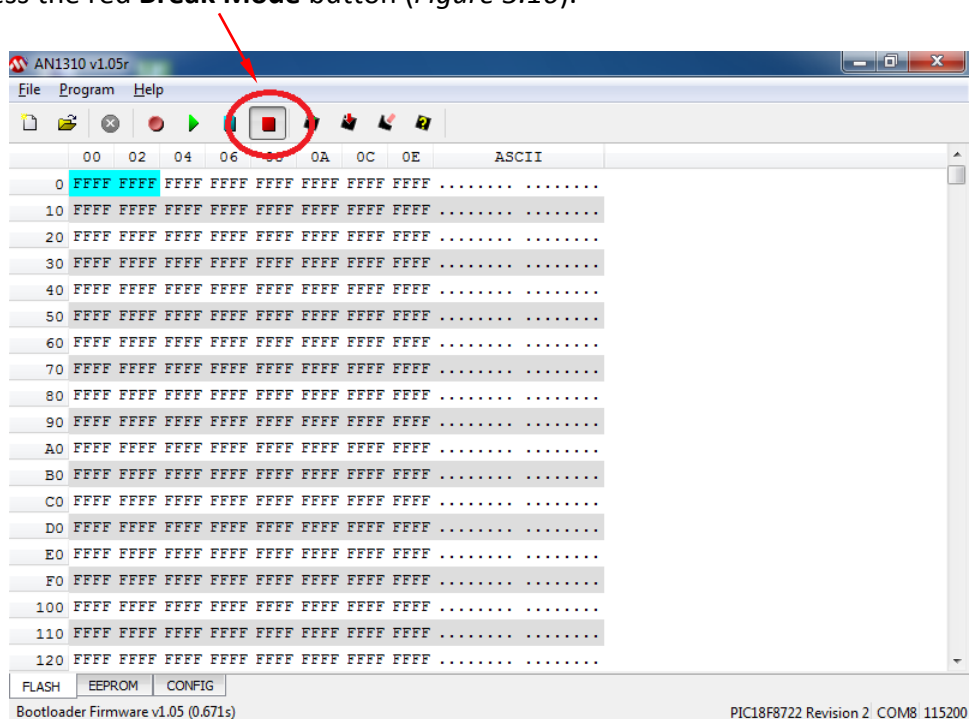
<p align="center">*Figure 3.16*</p>

6. From the main menu select **File>Open** (*Figure 3.17*)
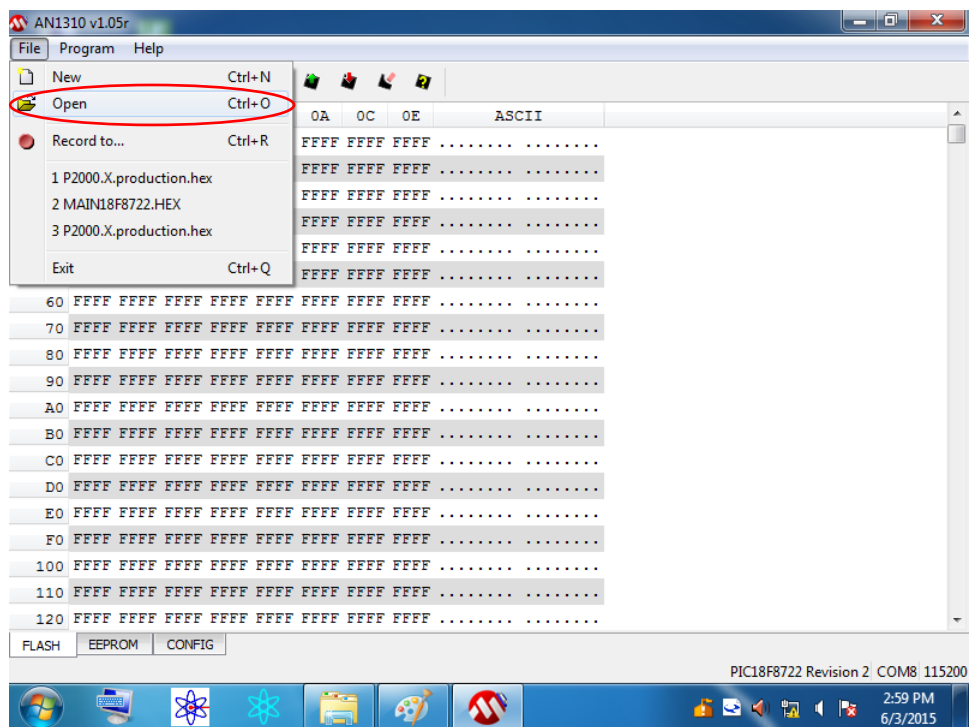
<p align="center">*Figure 3.17*</p>

7. Select the **FGA.detector.production.hex** file located in **C:\ATOM!** directory and click **Open** (*Figure 3.18*).
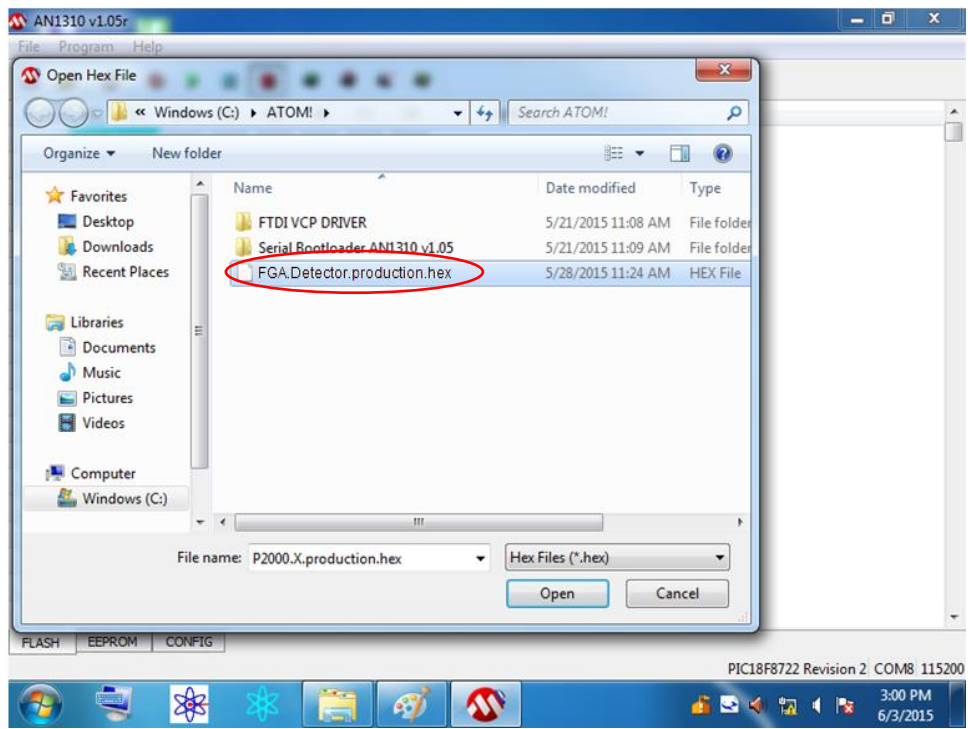
Figure 3.18

8. The bootloader screen will show new hexadecimal values. Click the **Write Device** button (*Figure 3.19*).
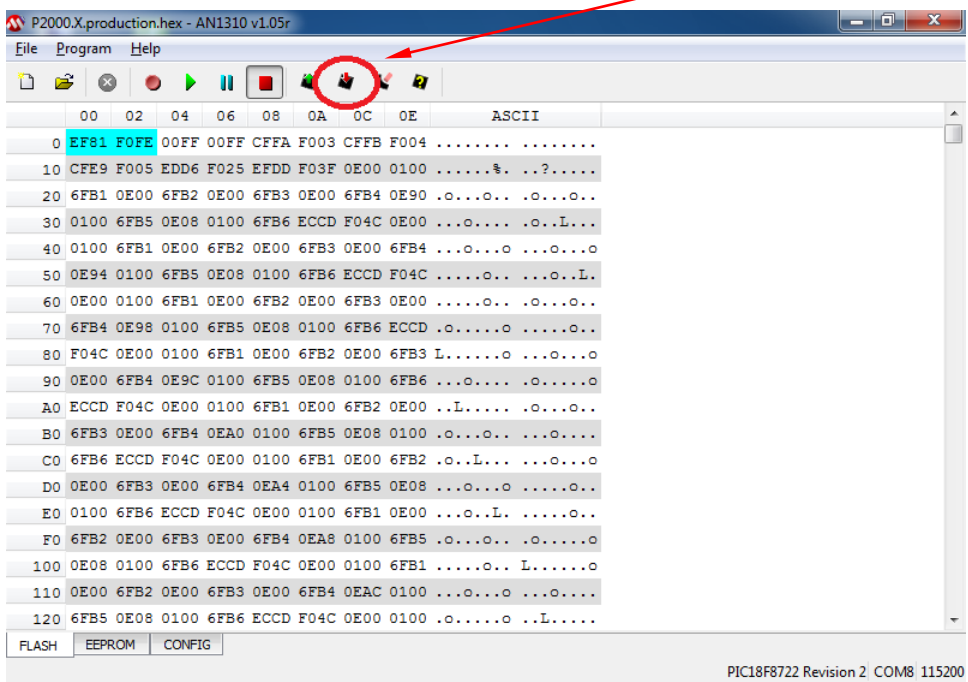
Figure 3.19

9. The bootloader software will replace the old firmware in the SP-2000 board with the new one. The bottom status bar will indicate "Write complete" when this step is completed (*Figure 3.20*).
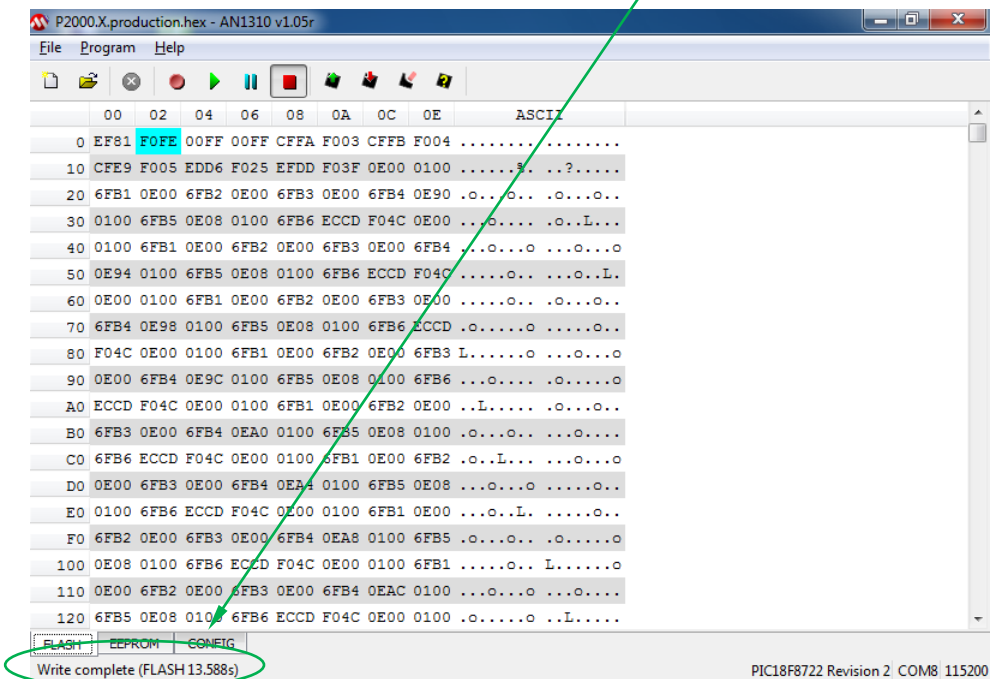
Figure 3.20

10. Close the bootloader software (*Figure 3.21*).
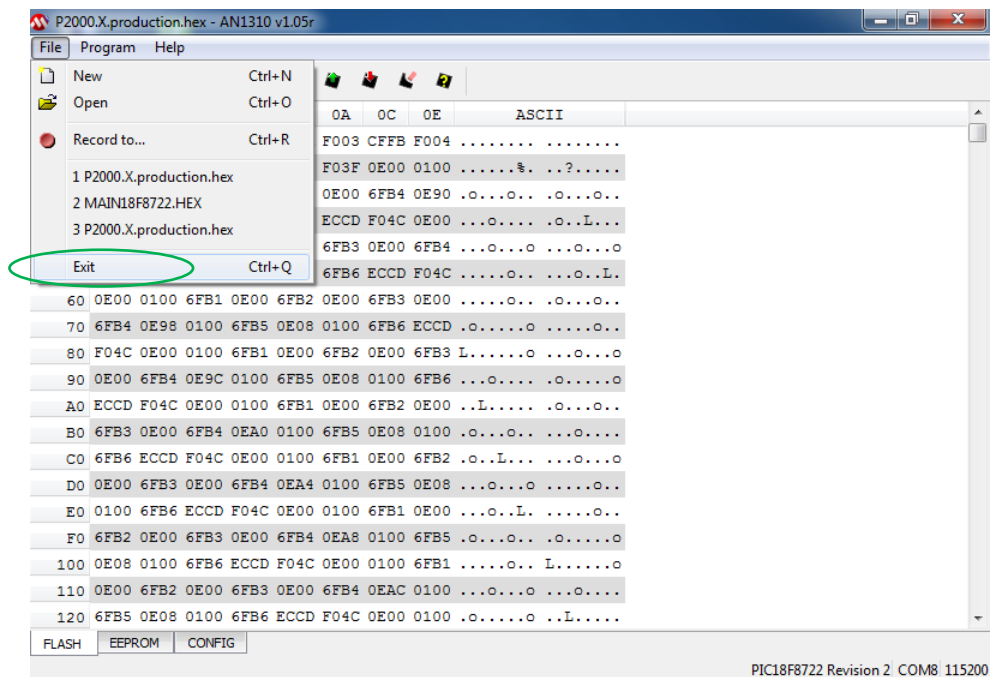
Figure 3.21

11. Press and hold the Reset button on the SP-2000 board for 2 seconds to complete this procedure.

12. Restart the computer, and both the ATOM and the GUI programs will automatically start up.

    Once the GUI is up and running, verify that all the settings on the Calibrate, Detector, System, and Timed Events Settings have been preserved. If not, manually enter these settings before re-starting the analysis.

Section 4 – FGA-1000 MODBUS Digital Communications

Section 4.1 Customer Connections

The FGA-1000 System supports both RS485 half-duplex and RS422 full-duplex communication for client access to the ATOM Database. User communications cable should be connected as specified below, depending upon COM type.

The COM 4 Port on the touchscreen computer which includes a DB-9 connector and associated label with communication signals is assigned to the following Pins:

	RS-485	RS-422
1 TX-	X	X
2 TX+	X	X
3 RX-		X
4 RX+		X
5 GND	X	X

The DB-9 pins are connected to a terminal strip within the FGA-1000 Main Electronics Enclosure. Locate the User Connection Terminal Strip within the FGA cabinet
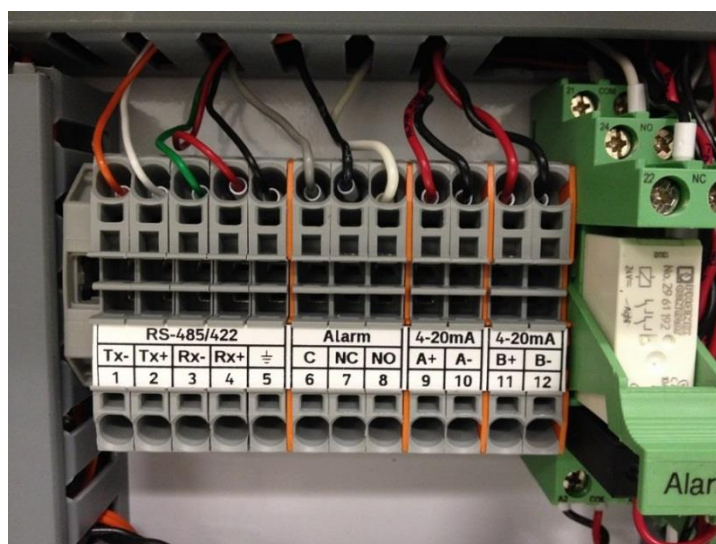
For MODBUS RS-485: Connect to terminals 1,2,5

For MODBUS RS-422: Connect to terminals 1,2,3,4,5

Section 4.2 Communication Settings

There are two sets of communication parameters displayed on the ATOM program, the Detector and Client communications.
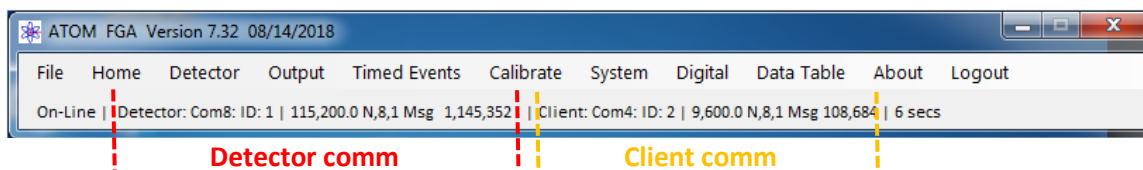
The Detector communication settings are intrinsic to communication between the Detector PC board and the ATOM program, and the Client communication settings are intrinsic to communication between the DCS / PLC and the ATOM program. These settings can be modified by editing the *Atom.exe.config* file.
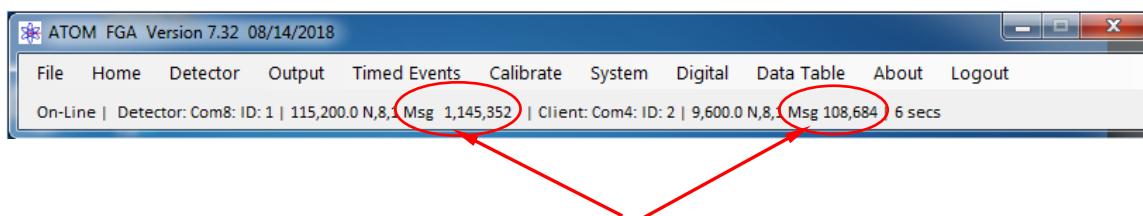
In addition to the communication settings, the "Msg" (message) counters when incrementing give a real-time indication of active communication between the respective modules. If either of the message counter is passive, it is an indication that communication has either been lost or aborted and user intervention may be required to restore it.

> *Note*: the above communication settings are crucial for operation and any modifications could lead to Analyzer operation failure. Please contact ATOM Instrument if you need more information about modifying these settings. The only recommended setting change is the "Analyzer Slave ID", and is explained in the following section (typically required ONLY if setting up DCS communication with multiple ATOM Analyzers).

Setting up Analyzer Slave ID for communication with the DCS/PLC:

The Analyzer Slave ID setting can be programmed by editing the *Atom2.exe.config* file.

Navigate to the Atom2.exe.config file located in **C:\ATOM!** directory. Right-click on the file and when the selection menu opens, select "Open with.." and choose the Notepad program to edit the config file.

When the file opens in Notepad, locate the <add key="ID_Slave" value="2"> setting as shown in *Figure 4.1*. This value is the unique ID that identifies each analyzer on the network to the DCS. Change the value to a desired number, then click on "File → Save", and then Exit the program.

Start the ATOM programs by double-clicking on the "Atom FGA Vxxx(A2)" desktop shortcut – this will automatically start both the ATOM and GUI programs.

```
<?xml version="1.0" encoding="utf-8"?>
<configuration>
  <startup>
    <supportedRuntime version="v4.0" sku=".NETFramework,Version=v4.5" />
  </startup>

<!--</connectionStrings>-->
  <appSettings>
    <add key="ID_SELF" value="1" />
    <add key="COM_D1" value="8" />
    <add key="COM_D2" value="4" />
    <add key="Baud_D1" value="115200" />
    <add key="Baud_D2" value="9600" />
    <add key="ID_Detector" value="1" />
    <add key="ID_Slave" value="2" />
    <add key="Timeout_D1" value="100" />
    <add key="HelperTools" value="0" />
    <add key="UseCorrectedPD" value ="0"/>
    <add key="ShowTC2" value ="0"/>
    <add key="Automatic_Restart" value="1"/>
    <add key="TC2_Timer1_Warn" value="86400"/>
    <add key="TC2_Timer2_Shutdown" value="86400"/>
    <add key="Version" value="7.41" />
    <add key="NoActivityTime" value="1800"/>
    <add key="EnableThermoCoupleFailureAlgorithm" value="0"/>
    <add key="Enable_TC1_3_Filtering" value ="1"/>
    <add key="DisableFirstOrderCorrection" value="1"/>
    <add key="SQL_Connection_String" value="Data Source=.\sqlexpress;
              Initial Catalog=ATOM_ONLINE_DB;Integrated Security=True;
              user id=sa1;password=sa12; MultipleActiveResultSets=True" />
    <add key="SW_Type" value="SLA" />
    <add key="ClientSettingsProvider.ServiceUri" value="" />
  </appSettings>
  <system.web>
    <membership defaultProvider="ClientAuthenticationMembershipProvider">
      <providers>
        <add name="ClientAuthenticationMembershipProvider" type="System.web.
              ClientServices.Providers.ClientFormsAuthenticationMembershipProvider,
              System.Web.Extensions, Version=4.0.0.0, Culture=neutral,
              PublicKeyToken=31bf3856ad364e35" serviceUri="" />
      </providers>
    </membership>
    <roleManager defaultProvider="ClientRoleProvider" enabled="true">
      <providers>
        <add name="ClientRoleProvider" type="System.web.ClientServices.Providers.
              ClientRoleProvider, System.Web.Extensions, Version=4.0.0.0,
              Culture=neutral, PublicKeyToken=31bf3856ad364e35" serviceUri=""
              cacheTimeout="86400" />
      </providers>
    </roleManager>
  </system.web>
</configuration>
```

Figure 4.1

If the ATOM successfully establishes communication with the DCS, the message counter on the right hand side of the ATOM program (as shown below in *Figure 4.2*) will start incrementing.
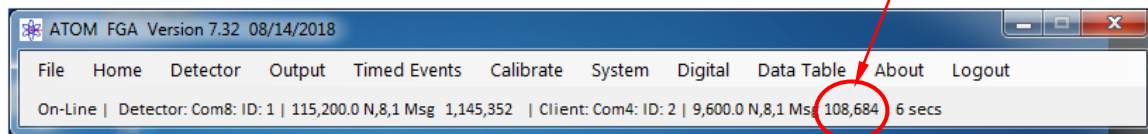
Figure 4.2

If the ATOM and the DCS are **not** communicating, the message counter will either read "0", or will not increment.

Section 4.3 MODBUS Function Code Description

The ATOM FGA-1000 is a "MODBUS Slave" while the client (DCS/PLC) is the "MOSBUS Master". All commands supported are 8-byte length as described below:

|Address ID| Function code |Start Ho|Start Lo|Data #pts Ho|Data #pts Lo|CRC0|CRC1|

Where:
- Address ID is the address that the station ID ATOM software must find to start a message.
- Function code is a value 1 to 6 declaring what function is to be performed (see below).
- Start HO is the starting register higher order 8-bits. Start LO is the starting register lower order 8-bits.These two bytes are concatenated to create a 16-bit number used in the data base.
- Data #pts Ho and Data #pts Lo are two bytes concatenated to specify the number of registers designated in the MODBUS message.
- CRC0 and CRC1 are two bytes concatenated to specify the CRC of the MODBUS message. Security is maintained by computing the CRC of the message first six bytes and comparing to the last two bytes for a match. A message is not processed if the two CRC's do not match.

- Function code 1: Read Relay coils (R1-R32 range).
- Function code 2: Read Input Status Registers (R10001-R10032 range).
- Function code 3: Read discrete 16-bit holding Registers (R40001-R40040 range).
- Function code 3: Read discrete 32-bit holding Registers (R40041-R40120 range) where: R40041-42 is the first par, R40119-120 is the last pair.
- Function code 4: Read output 32-bit register pairs (R3001-R30082 range) where: R30001-02 is first pair, R30081-R30082 is last pair.
- Function code 4: Read output 16-bit registers (R30083-R30120 range) where: range is 16-bit registers.
- Function code 5: set relay coil register (R1-R40).
- Function code 6: preset single holding register (R40001-R40120).

The double registers specified in function code 3 and 4 must be recognized as 32-bit data to interpret it properly.

Section 4.5 Reading Algorithm

The MODBUS data is typically a near continuous stream of data packets from the Client. The ATOM software is self-aligning regardless of where it starts listening to packets. This is accomplished by starting with an index of zero. The byte read must equal the Station ID if the index is zero. If not, the alignment procedure begins again without incrementing the index. Alignment is achieved within 8 characters of a packet for the ATOM FGA-1000. When a character read does equal the ID, the index is advanced from 0 to 1. The next character read must equal an allowable function code (1-6). If there is no match the index is reset to 0. Under this scenario, the reception of packets will self-synchronize. If we have a match on the first and second byte, read the next 6 bytes. At this point we have 8 bytes in a receive register. Perform a CRC on the first six characters and compare with the 7th and 8th characters. There must be a CRC match to process the received packet. If there is no match, the index is again reset to 0 and the process of data

capture and qualification repeats. Upon detection of a complete and valid packet the received 8-byte packet is transferred to private processing area. The "Save Packet" function is called which executes a function (1-6) as defined by the function code byte in the 2nd byte of the saved packet. The ATOM software creates a reply message for the Client and transmits it back to the client. A message stream resembles the image below showing the command on the left and the response on the right.

Response time is approximately 10ms after the packet is decoded before a reply message is sent.

Example of reading a single unsigned 32-bit register

In the example below, registers pair R30169 and R30170 are the ppm value. Use function code 4 with an offset of 68 in the MODBUS message to read it.

Example MODBUS query: **02 04 00 44 00 02 31 ED**

Where:
02 = ID
04 = Function Code
00 44 = address offset = 68
00 02 = number of registers requested
31 ED = CRC

Example of MODBUS response, returns 4 bytes from offset 68 : **02 04 04 00 07 B1 84 0D 76**

Where:
02 = ID
04 = Function Code
04 = Byte Count
00 07 B1 84 = 504,196 ppm
0D 76 = CRC

Section 4.6 ATOM Instrument FGA1000 MODBUS Map

The MODBUS Data Model presents six database areas that FGA1000 data may be read from or written to. The areas are defined as follows:

ATOM MODBUS Database Model			
Database Area	Name	Register Designation	Default Data Type
1	Coils/Boolean	00001 – 00064	Boolean
2	Input Status	10001 – 10080	Boolean
3	Input Register pairs	30001 – 30080	32-bit Integer
4	Input Register	30081 – 30120	16-bit Integer
5	Input Register pairs	30121 – 30342	32-bit Integer
6	Holding Register	40001 – 40080	16-bit Integer
7	Holding Register	40081 – 40240	32-bit Integer

Each discrete data element within the MODBUS database is called a register. Register addressing resolves the database area in which it resides as well as the element offset within the area. For example, the register address of 30083 indicates the integer value stored in register 83 within the Input Registers data base area. MODBUS address 00004 indicates the current Boolean value in register 4 of the Discrete Coil Register area in the data base.

Another aspect of the MODBUS register convention is that some registers are Read-Only from the Host system while other areas are **Read/Write**.

- The Input Status Registers (1xxxx) and the Output Status registers (3xxxx) are Read-Only registers. The Host system is only able to read the values placed into these register areas.

- The Coil Registers (0xxxx) and the Holding Register (4xxxx) are Read/Write registers. The host has read/write access to the registers in these areas. These areas are where Command and Operating Parameter values are written from the Host system. Read only data from the field unit can be placed into these registers as well.

Registers in 3xxxx and 4xxxx range have segments dedicated for 32-bit Integers. These registers require two sequential 16-bit registers. See description in the map.

This data base exists to allow communication from/to the FGA1000 to the ATOM Scanner/GUI program and a RS-485 link for a MODBUS client system.

Controls at the ATOM Scanner program allow the administrator to program the COM Port, Baud Rate and MODBUS ID for the ATOM Scanner and the RS485 Client link.

Client Access: Although the entire ATOM database is available, a client may only have interest in certain data areas. Here is a selection of typical monitor points.

10004	Process State	Process status (Boolean)
10008	Alarm State	Global Alarm (Boolean) Status 0= Alarm, 1=NO Alarm
10019	Purging	1=Purging in progress (Boolean)
10024	Calibrating	1=Calibration in Progress (Boolean)
10025	Running	Status 1= In Run Mode (Boolean)
10026	Holding	1=Status IDLE ("Holding" mode)
10032	Fresh Data	"1" indicates Fresh Data (auto cleared at the end of next peak acquisition while in Process state)
30069-30070	CyclePPM	PPM of current cycle run (process/calibration)

Minimal client monitoring algorithm:

The client could read 10001-10040 (5-bytes) twice per minute for changes in system status. Registers 30069-30070 could be read when the fresh data flag sets. At least 70 seconds elapses before "Fresh Data" self clears for the next cycle.

Discrete Coil Registers

Range 00001-00064

R#	Mnemonic	Description (Boolean Commands)
1	New SRN	1=New Sequential Record Number written
2	ARun	Start/Stop a RUN; 0=Stop, 1=Start
3	Calibrate Check Zero	Start/Stop a Calibrate Zero Function, 1=Start
4	Calibrate Check Span	Start/Stop a Calibrate Span Function, 1=Start
5	Calibrate Validate	Start/Stop a Validate Function, 1=Start
6	Manual Zero Set	1=manually zero the baseline (Home Screen)
7	Maintenance	Analyzer 0=Online; 1=Offline
8	Reserved	
9	Calculate RF	1=Calculate the Response Factor (RF)
10	Override	Purge Override 1=ON, 0=OFF
11	Reserved	
12	BL_Enable	1=Base Line Enable for "Zero Baseline" (Detector Settings)
13	Lamp State	Lamp On/Off Control; 0=OFF, 1=ON
14	PMT State	PMT On/Off Control; 0=OFF, 1=ON
15	Auto Cal Enable	1=Automatic Calibrate Enable
16	Reserved	
17	SV State DO	S/V (Sample Valve) 0=OFF, 1=ON (test control of DO)
18	SSO State DO	SSO 0=OFF, 1=ON (test control of DO)
19	Calibrate State DO	Calibrate (test control of DO)
20	Process State DO	Process (test control of DO)
21	Zero State DO	Zero (test control of DO)
22	Span State DO	Span (test control of DO)
23	Validate State DO	Validate (test control of DO)
24	Alarm State DO	Alarm Status (test control of DO)
25	Playback	Control of recorded data playback 0=OFF, 1=ON (Demo Mode)
26	Auto Cal Event	Not user programmable – internal use
27	Reserved	
28	Reserved	
29	Cal Parm Change	Is set to "1" if any Cal parameters have been modified – internal use
30	Save RF	Saves the new calculated RF
31	Reserved	
32	Check Sum Request	Set to "1" to request Checksum from ATOM
33	Stream 1 Enable	1=Stream1 selected (Home Screen Checkbox)
34	Stream 2 Enable	1=Stream2 selected (Home Screen Checkbox)
35	Reserved	
36	Reserved	
37	Thermocouple Warn	Not user programmable – internal use

38	TC1 Set Point Changed	Not user programmable – internal use
39	TC2 Set Point Changed	Not user programmable – internal use
40	TC3 Set Point Changed	Not user programmable – internal use
41	MFC1 Set Point Changed	Not user programmable – internal use
42	MFC2 Set Point Changed	Not user programmable – internal use
43	MFC3 Set Point Changed	Not user programmable – internal use
44	Enable/Disable TC2 algorithm	0=Disable, 1=Enable – internal use
45	Disable/Enable PD Correction algorithm	1=Disable, 0=Enable – internal use
46 - 64	Reserved	

Discrete Input Status Registers
Range: 10001-10080

R#	Mnemonic	Description (connected to physical outputs)
10001	SV State	Inject/Vent Valve (S/V) Status 1=inject
10002	SSO State	SSO (sample Shut Off) 1=ON, 0=OFF
10003	Calibrate State	Calibrate Status
10004	Process State : FGA	Process Status
10005	Zero State	Zero Calibration Status
10006	Span State	Span Calibration Status
10007	Validate State	Validate Calibration Status
10008	Alarm State	Global Alarm Status 0= Alarm, 1=NO Alarm

R#	Mnemonic	Description (8 bits mapped to physical inputs)
10009	DI1	Digital Input 1 – Loss of Purge
10010	DI2	Digital Input 2 – O2 Pressure Low
10011	DI3	Digital Input 3 – Furnace Temp Low
10012	DI4	Digital Input 4 – user programmable
10013	DI5	Digital Input 5 – user programmable
10014	DI6	Digital Input 6 – user programmable
10015	DI7	Digital Input 7 – user programmable
10016	DI8 (D09)	Read back of Purge Override state

R#	Mnemonic	Description (Boolean Status)
10017	Overriding	1=currently in Purge Override; 0=not in Purge Override
10018	New Cycle Request	Indicates if another cycle is in queue to run – for internal use
10019	Purging	1=Purging in Progress
10020	Check Sum Complete	0=currently performing or not yet performed checksum; 1=has completed a checksum – for internal use
10021	BL_Corrected	Data has been offset by baseline corrected value
10022	Logging	Logging to Data Base – for internal use
10023	Reserved	
10024	Calibrating	1=Calibration in Progress (SGA/SLA)
10025	Running	1=In Run Mode
10026	Holding	1=Status IDLE ("Holding" mode)
10027	Stop Pending	Indicates that Atom will go into HOLD state at end of current run
10028	Injecting	1=Inject Event (sample being injected)
10029	Fresh Reading	1=new reading posted after computed peak – can be process or calibrate data
10030	Event Base Line	1=Event Base Line acquisition
10031	Event Peak	1=Event Peak acquisition

10032	Fresh Data	1=Fresh Stream/Process only Data available
10033	MFC1 Status	1=value out of range of the set lower or upper limits
10034	MFC2 Status	1=value out of range of the set lower or upper limits
10035	TC1 Status	1=value out of range of the set lower or upper limits
10036	TC2 Status	1=value out of range of the set lower or upper limits
10037	Span Status	1=value out of range of the set lower or upper limits
10038	Zero Status	1=value out of range of the set lower or upper limits
10039	Stream 1 Status	1=value out of range of the set lower or upper limits
10040	TC3 Status	1=value out of range of the set lower or upper limits
10041	Check Sum Valid	1=valid checksum; 0=error – can be used as a debugging tool.
10042	Stream1FreshData	1=fresh Stream1 process data available
10043	Stream2FreshData	1=fresh Stream2 process data available
10044	Stream 1 State	1=currently running; 0=not currently running
10045	Stream 2 State	1=currently running; 0=not currently running
10046	Process State	For internal use
10047	Calibrate State	For internal use
10048	Stream 2 Status	1=value out of range of the set lower or upper limits
10049	Zero Signal	1=selected and in queue
10050	Span Signal	1=selected and in queue
10051	Validate Signal	1=selected and in queue
10052	User Halt Signal	1=selected and in queue
10053	User Start Signal	1=selected and in queue
10054	Reserved For Q	Not available
10055	Reserved For Q	Not available
10056	Reserved For Q	Not available
10057	TC2 failure	1=thermocouple has failed and analyzer has been stopped
10058	MFC3 status	1=value out of range of the set lower or upper limits
10059 - 80	Reserved	

Discrete Output Registers

Range: 30001-30342

R#	Mnemonic	Description (32-bit RO registers)
30001-30002	Defined	Defined space for s/w use
30003-30004	Uncorrected ppb Stream1	For internal use
30005-30006	Uncorrected ppb Stream2	For internal use
30007-30022	Reserved	
30023-30024	MFC3 Set point Readback	Readback of set point
30025-30026	MFC1 Set point Readback	Readback of set point
30027-30028	MFC2 Set point Readback	Readback of set point
30029-30030	TC1 Set point Readback	Readback of set point
30031-30032	TC2 Set point Readback	Readback of set point
30033-30034	TC3 Set point Readback	Readback of set point
30035-30036	MFC3 value	Mass Flow Controller 3 Value
30037-30038	Applied uV	Applied Baseline offset in microvolts
30039-30040	BL_Temp_Corrected	For internal use
30041-30042	Which Stream	Defined space for s/w use
30043-30044	MFC1Value	Mass Flow Controller 1 Value
30045-30046	MFC2Value	Mass Flow Controller 2 Value
30047-30048	TC1 Value	Temperature Controller 1 Value
30049-30050	TC2 Value	Temperature Controller 2 Value
30051-30052	TC3 Value	Temperature Controller 3 Value
30053-30054	Reserved	
30055-30056	Reserved	
30057-30058	PMT ave	PMT average (signed 32-bit)
30059-30060	Elapse Seconds	Seconds elapsed since start of current cycle (as seen on Home Screen)
30061-30062	Reserved	
30063-30064	PD average	Photo Diode 1 sec average
30065-30066	Base Line Average	baseline average in detector counts
30067-30068	Area Of Peak Process	Process (FGA) peak area in detector counts
30069-30070	CyclePPM	PPM of current cycle run (process/calibration)
30071-30072	mV_Out	PMT reading in millivolts
30073-30074	uV_Out	PMT reading in microvolts
30075-30076	Area Of Peak Stream 2	Stream 2 peak area in detector counts
30077-30078	DCRFDivisor	Avg Lamp Intensity during baseline of latest cycle - For internal use
30079-30080	Cycle_ppb	PPB of current cycle run (process/calibration)

R#	Mnemonic	Description (16-bit RO registers)
30081	RawTC2value	TC2 value before applying filter - For internal use
30082	RawTC2SP	TC2 set point value before applying filter - For internal use
30083	Reserved	
30084	PCT_FS_DAC1	% of Full Scale for DAC1
30085	TC77_Sensor	On-board Temperature in °C (scaled)
30086	Demo Code	Value between 0-3; selects a preset concentration for playback
30087	CycleNum	Number of current cycle since start of analyses (on Home Page)
30088	Warn States	Bit definitions of WARN checkboxes on System Settings screen
30089	Numbr Cycles	Increments at the end of any cycle. Resets when analysis switches to the next zero, span, validate or process is started.
30090	Alarm Status	Reflected on the Home Screen, 0=no Alarm, 1=Warning, 2=Alarm
30091	Cycleppm (scaled)	For internal use
30092	Version Num	Firmware version ID
30093	PCT_FS_DAC2	% of Full Scale for DAC2
30094	Date Code	Days since 1-1-1900 – 32768 (s/w release)
30095	Reserved	
30096	Override Timer	Secs remaining in cabinet purge override
30097	Numbr Cal Cycles	Current calibration cycle number being run
30098	Alarm States	Bit definitions of ALARM checkboxes on System Settings screen
30099	Stream 1 Progress	Number of current Stream 1 cycle being run out of total requested
30100	Stream 2 Progress	Number of current Stream 2 cycle being run out of total requested
30101	Density Reading S1	Density of Stream 1 - Value used to correct Stream 1 concentration (for SLA only)
30102	Density Reading S2	Density of Stream 2 - Value used to correct Stream 2 concentration (for SLA only)
30103	Alarm Hysteresis	Bit definitions of ALARM checkboxes on System Settings screen
30104	Warn Hysteresis	Bit definitions of WARN checkboxes on System Settings screen
30105	MFC3 Alarm State	Bit definitions of ALARM checkboxes on System Settings screen (extended to incorporate MFC3)
30106	MFC3 Warn State	Bit definitions of WARN checkboxes on System Settings screen (extended to incorporate MFC3)
30107-30120	Reserved	

R#	Mnemonic	Description (32-bit RO registers)
30121-30122	PA1_S2 (Stream 2-1 Area)	Concentration for Stream 2 Peak Area 1 – scrolling array of 10 concentration values in ppm x 100. Oldest data if the array over-written each cycle.
30123-30124	PA1_S2 (Stream 2-2 Area)	Concentration for Stream 2 Peak Area 2
30125-30126	PA1_S2 (Stream 2-3 Area)	Concentration for Stream 2 Peak Area 3
30127-30128	PA1_S2 (Stream 2-4 Area)	Concentration for Stream 2 Peak Area 4
30129-30130	PA1_S2 (Stream 2-5 Area)	Concentration for Stream 2 Peak Area 5
30131-30132	PA1_S2 (Stream 2-6 Area)	Concentration for Stream 2 Peak Area 6
30133-30134	PA1_S2 (Stream 2-7 Area)	Concentration for Stream 2 Peak Area 7
30135-30136	PA1_S2 (Stream 2-8 Area)	Concentration for Stream 2 Peak Area 8
30137-30138	PA1_S2 (Stream 2-9 Area)	Concentration for Stream 2 Peak Area 9
30139-30140	PA1_S2 (Stream 2-10 Area)	Concentration for Stream 2 Peak Area 10
30141-30142	PA1_S1 (Process -1 Area)	Concentration for Process Peak Area 1 – scrolling array of 10 concentration values in ppm x 100. Oldest data if the array over-written each cycle.
30143-30144	PA1_S1 (Process -2 Area)	Concentration for Process Peak Area 2
30145-30146	PA1_S1 (Process -3 Area)	Concentration for Process Peak Area 3
30147-30148	PA1_S1 (Process -4 Area)	Concentration for Process Peak Area 4
30149-30150	PA1_S1 (Process -5 Area)	Concentration for Process Peak Area 5
30151-30152	PA1_S1 (Process -6 Area)	Concentration for Process Peak Area 6
30153-30154	PA1_S1 (Process -7 Area)	Concentration for Process Peak Area 7
30155-30156	PA1_S1 (Process -8 Area)	Concentration for Process Peak Area 8
30157-30158	PA1_S1 (Process -9 Area)	Concentration for Process Peak Area 9
30159-30160	PA1_S1 (Process -10 Area)	Concentration for Process Peak Area 10
30161-30162	S1_Cycle_ppb	Most recent Stream 1 cycle conc in ppb
30163-30164	S2_Cycle_ppb	Most recent Stream 2 cycle conc in ppb
30165-30166	Ppb Process 1	Scrolling array of 10 values with most recent Process concentration in ppb in these registers
30167-30168	Ppb Process 2	Concentration for Process ppb 2
30169-30170	Ppb Process 3	Concentration for Process ppb 3
30171-30172	Ppb Process 4	Concentration for Process ppb 4
30173-30174	Ppb Process 5	Concentration for Process ppb 5
30175-30176	Ppb Process 6	Concentration for Process ppb 6
30177-30178	Ppb Process 7	Concentration for Process ppb 7
30179-30180	Ppb Process 8	Concentration for Process ppb 8
30181-30182	Ppb Process 9	Concentration for Process ppb 9
30183-30184	Ppb Process 10	Concentration for Process ppb 10
30185-30186	Ppb Process ave	Average Concentration in ppb of preset numbers of cycles for Process
30187-30188	Span ppb Cal 1	Scrolling array of 10 values with most recent Span concentration in ppb in these registers
30189-30190	Span ppb Cal 2	Concentration for Span ppb 2
30191-30192	Span ppb Cal 3	Concentration for Span ppb 3

30193-30194	Span ppb Cal 4	Concentration for Span ppb 4
30195-30196	Span ppb Cal 5	Concentration for Span ppb 5
30197-30198	Span ppb Cal 6	Concentration for Span ppb 6
30199-30200	Span ppb Cal 7	Concentration for Span ppb 7
30201-30202	Span ppb Cal 8	Concentration for Span ppb 8
30203-30204	Span ppb Cal 9	Concentration for Span ppb 9
30205-30206	Span ppb Cal 10	Concentration for Span ppb 10
30207-30208	Span ppb Cal ave	Average Concentration in ppb of run cycles for Span
30209-30210	Checksum	Output of detector firmware checksum - For internal use
30211-30212	PPBA1_S2 (Stream 2 ppb)	Scrolling array of 10 values with most recent Stream 2 concentration in ppb in these registers
30213-30214	PPBA2_S2 (Stream 2 ppb)	Concentration for Stream 2 ppb 2
30215-30216	PPBA3_S2 (Stream 2 ppb)	Concentration for Stream 2 ppb 3
30217-30218	PPBA4_S2 (Stream 2 ppb)	Concentration for Stream 2 ppb 4
30219-30220	PPBA5_S2 (Stream 2 ppb)	Concentration for Stream 2 ppb 5
30221-30222	PPBA6_S2 (Stream 2 ppb)	Concentration for Stream 2 ppb 6
30223-30224	PPBA7_S2 (Stream 2 ppb)	Concentration for Stream 2 ppb 7
30225-30226	PPBA8_S2 (Stream 2 ppb)	Concentration for Stream 2 ppb 8
30227-30228	PPBA9_S2 (Stream 2 ppb)	Concentration for Stream 2 ppb 9
30229-30230	PPBA10_S2 (Stream 2 ppb)	Concentration for Stream 2 ppb 10
30231-30232	PPBave_S2 (Stream 2 ppb)	Average Concentration in ppb of preset numbers of cycles for Stream 2
30233-30234	Zero Area 1 Calibrate	Scrolling array of 10 values with most recent Zero Area in these registers
30235-30236	Zero Area 2	Zero Calibration Area 2
30237-30238	Zero Area 3	Zero Calibration Area 3
30239-30240	Zero Area 4	Zero Calibration Area 4
30241-30242	Zero Area 5	Zero Calibration Area 5
30243-30244	Zero Area 6	Zero Calibration Area 6
30245-30246	Zero Area 7	Zero Calibration Area 7
30247-30248	Zero Area 8	Zero Calibration Area 8
30249-30250	Zero Area 9	Zero Calibration Area 9
30251-30252	Zero Area 10	Zero Calibration Area 10
30253-30254	Zero Area Ave Calibrate	Avg Area of run cycles for Zero Calibration
30255-30256	Zero ppb 1 Calibrate	Scrolling array of 10 values with most recent Zero concentration in ppb in these registers
30257-30258	Zero ppb 2 Calibrate	Concentration for Zero ppb 2
30259-30260	Zero ppb 3 Calibrate	Concentration for Zero ppb 3
30261-30262	Zero ppb 4 Calibrate	Concentration for Zero ppb 4
30263-30264	Zero ppb 5 Calibrate	Concentration for Zero ppb 5
30265-30266	Zero ppb 6 Calibrate	Concentration for Zero ppb 6
30267-30268	Zero ppb 7 Calibrate	Concentration for Zero ppb 7
30269-30270	Zero ppb 8 Calibrate	Concentration for Zero ppb 8

30271-30272	Zero ppb 9 Calibrate	Concentration for Zero ppb 9
30273-30274	Zero ppb 10 Calibrate	Concentration for Zero ppb 10
30275-30276	Zero ppb Ave Calibrate	Average Concentration in ppb of preset numbers of cycles for Zero
30277-30278	Span 1 Area Calibrate	Scrolling array of 10 values with most recent Span Area in these registers
30279-30280	Span 2 Area Calibrate	Span Calibration Area 2
30281-30282	Span 3 Area Calibrate	Span Calibration Area 3
30283-30284	Span 4 Area Calibrate	Span Calibration Area 4
30285-30286	Span 5 Area Calibrate	Span Calibration Area 5
30287-30288	Span 6 Area Calibrate	Span Calibration Area 6
30289-30290	Span 7 Area Calibrate	Span Calibration Area 7
30291-30292	Span 8 Area Calibrate	Span Calibration Area 8
30293-30294	Span 9 Area Calibrate	Span Calibration Area 9
30295-30296	Span 10 Area Calibrate	Span Calibration Area 10
30297-30298	Span Area Ave Calibrate	Avg Area of run cycles for Span calibration
30299-30300	Validate 1 ppb	Scrolling array of 10 values with most recent Validate concentration in ppb in these registers
30301-30302	Validate 2 ppb	Concentration for Validate ppb 2
30303-30304	Validate 3 ppb	Concentration for Validate ppb 3
30305-30306	Validate 4 ppb	Concentration for Validate ppb 4
30307-30308	Validate 5 ppb	Concentration for Validate ppb 5
30309-30310	Validate 6 ppb	Concentration for Validate ppb 6
30311-30312	Validate 7 ppb	Concentration for Validate ppb 7
30313-30314	Validate 8 ppb	Concentration for Validate ppb 8
30315-30316	Validate 9 ppb	Concentration for Validate ppb 9
30317-30318	Validate 10 ppb	Concentration for Validate ppb 10
30319-30320	Validate 1 ppb Average	Average Concentration in ppb of preset numbers of cycles for Validate
30321-30322	Validate 1 Area	Scrolling array of 10 values with most recent Validate Area in these registers
30323-30324	Validate 2 Area	Validate Calibration Area 2
30325-30326	Validate 3 Area	Validate Calibration Area 3
30327-30328	Validate 4 Area	Validate Calibration Area 4
30329-30330	Validate 5 Area	Validate Calibration Area 5
30331-30332	Validate 6 Area	Validate Calibration Area 6
30333-30334	Validate 7 Area	Validate Calibration Area 7
30335-30336	Validate 8 Area	Validate Calibration Area 8
30337-30338	Validate 9 Area	Validate Calibration Area 9
30339-30340	Validate 10 Area	Validate Calibration Area 10
30341-30342	Validate Area Average	Avg Area of run cycles for Validate calibration

Discrete Input Register

Range: 40001-40240

R#	Mnemonic	Description (16-bit RW registers)
40001	Output Average Process	Number of process runs concentration to be averaged
40002	Inject Valve Start	Time in seconds from start of cycle to inject valve start
40003	Inject Valve Stop	Time in seconds from start of cycle to inject valve stop
40004	SSOValveStart	Time in seconds from start of cycle to SSO valve start
40005	SSOValveStop	Time in seconds from start of cycle to SSO valve stop
40006	Base Line Start	Cycle Time at which to start baseline acquisition
40007	Base Line Stop	Cycle Time at which to stop baseline acquisition
40008	Auto Zero Time	Time in secs in cycle when baseline is automatically zeroed (display only)
40009	Peak Start Time	Cycle Time at which to start peak acquisition
40010	Peak Stop Time	Cycle Time at which to stop peak acquisition
40011	Run Mode Cycle Sec	Duration in seconds for 1 cycle
40012	Instrument Status	Bit level definition of Analyzer status - For internal use
40013	Compat Last Zero	16-bit converted value of last run zero cycle
40014	Compat Last Span	16-bit converted value of last run span cycle
40015	State Flag	Bit level definition - last settings saved in EEPROM in case of power failure – For internal use
40016	Purge Seconds	Purge Time in seconds when mode switch occurs
40017	Reserved	
40018	Reserved	
40019	Reserved	
40020	FS_DAC1	Full Scale DAC1 in millivolts
40021	FS_DAC2	Full Scale DAC2 in millivolts
40022	Zero_DAC1	DAC1 lower value (output settings)
40023	Zero_DAC2	DAC2 lower value (output settings)
40024	Auto Cal Freq Days	Auto Calibration frequency in days
40025	Program ID (FGA/SGA/SLA sel)	For internal use
40026	Alarm Mask	Bit mask to enable/disable ALARM checkboxes on System Settings screen
40027	Cal Cycles	Number of calibration cycles set to run
40028	Averages	Smoothing filter setting (number between 1 and 8) – set on Detector Settings screen

40029	DAC1_PV	DAC1 process variable choice
40030	Cycle End	Cycle mode setting : 0=stop, 1=repeat, 2=hold; set on Detector Settings screen
40031	PMT_Volts	PMT Volts (value between 0 and 999)
40032	Compat Last Validate	16-bit converted value of last run validate cycle
40033	Number of Cycles	For internal use
40034	Compat Last Process	16-bit converted value of last run process cycle
40035	DAC2_PV	DAC2 process variable choice
40036	Cal Units	%, ppm, or ppb
40037	Override Minutes	Cabinet set purge override time in minutes
40038	Secs Until Repeat	Cycle hold time minimum before a new start event (Detector Settings screen)
40039	TOD_Cal	Time of Day for auto calibrate check, if enabled (hh * 60 + min)
40040	Warn Mask	Bit mask to enable/disable WARN checkboxes on System Settings screen
40041	Stream 1 Runs	Total cycles of Stream 1 set to run before switching
40042	Stream 2 Runs	Total cycles of Stream 2 set to run before switching
40043	Stream 1 Density	Density of Stream 1 - Value used to correct Stream 1 concentration for current cycle (for SLA only)
40044	Stream 2 Density	Density of Stream 2 - Value used to correct Stream 2 concentration for current cycle (for SLA only)
40045	Calibration Density	Density of the liquid span calibration standard used to calibrate instrument (for SLA only)
40046	Output Average Stream 2	Number of stream 2 runs concentration to be averaged
40047	MFC1 Initial Address	Currently programmed MFC1 address
40048	MFC1 Desired Address	New address that will be programmed into MFC1
40049	TC Failure Log	For internal use
40050	Alarm Mask2	Bit mask to enable/disable ALARM checkboxes on System Settings screen (extended to incorporate MFC3)
40051	Warn Mask2	Bit mask to enable/disable WARN checkboxes on System Settings screen (extended to incorporate MFC3)
40052	Starting Stream	Sets order of streams at start up – checkbox on Home Screen
40053-40057	Reserved	
40058	Count Of Violations	For internal use
40059	Defined	Defined space for s/w use

40060	MFC1 address	For future implementation
40061	MFC2 address	For future implementation
40062	MFC3 address	For future implementation
40063-40080	Reserved	

R#	Mnemonic	Description (32-bit RW registers)
40081-40082	Zero Cal Average Area	Zero cal avg area response value
40083-40084	Span Cal Average Area	Span cal avg area response value
40085-40086	Counts Per ppm	Computed detector counts per ppm = Response Factor
40087-40088	Zero Saved	Last saved zero value
40089-40090	Span_DAC1	High Value for DAC1
40091-40092	Span_DAC2	High Value for DAC2
40093-40094	BLOffset_uV	User input baseline offset value in uV
40095-40096	Span Cal ppb	Span cal conc ppb value
40097-40098	Zero Cal ppb	Zero cal conc ppb value
40099-40100	Last Validate ppm	Last value of Validate calibration conc in ppm
40101-40102	Span Saved	Last saved value of Span calibration
40103-40104	DCRF Multiplier	For Internal use
40105-40106	MFC1 Low	MFC1 Low range setting
40107-40108	MFC1 High	MFC1 High range setting
40109-40110	MFC2 Low	MFC2 Low Range setting
40111-40112	MFC2 High	MFC2 High Range setting
40113-40114	TC1 Low	TC1 Low Range setting
40115-40116	TC1 High	TC1 High Range setting
40117-40118	TC2 Low	TC2 Low Range setting
40119-40120	TC2 High	TC2 High Range setting
40121-40122	MFC 1 Set point	MFC 1 Set point setting
40123-40124	MFC2 Set point	MFC 2 Set point setting
40125-40126	TC1 Set point	TC 1 Set point setting
40127-40128	TC2 Set point	TC 2 Set point setting
40129-40130	TC3 Set point	TC 3 Set point setting
40131-40132	TC3 Low	TC 3 Low Range Setting
40133-40134	TC3 High	TC 3 High Range Setting
40135-40136	Zero Low Alarm	Zero Low alarm setting
40137-40138	Zero High Alarm	Zero High alarm setting
40139-40140	Span Low Alarm	Span Low alarm setting
40141-40142	Span High Alarm	Span High alarm setting
40143-40144	Stream 1 Low Alarm	Stream 1 Low alarm setting
40145-40146	Stream 1 High Alarm	Stream 1 High alarm setting
40147-40148	Reserved	
40149-40150	RF Value	User entered RF value (RF value in use)
40151-40152	Reserved	
40153-40154	Zero Value Interference Correct	For Internal use

40155-40156	Timer 1 warn	For Internal use
40157-40158	Timer 2 shutdown	For Internal use
40159-40160	Reserved	
40161-40162	Stream 2 Low Alarm	Stream 2 Low alarm setting
40163-40164	Stream 2 High Alarm	Stream 2 High alarm setting
40165-40166	MFC3 Low Alarm	MFC3 Low alarm setting
40167-40168	MFC3 High Alarm	MFC3 High alarm setting
40169-40170	MFC3 Set point	MFC 3 Set point setting
40171-40240	Reserved	

Section 5 – ATOM Scanner Features and Operation

Section 5.1 ATOM Logs

There are three event log files generated by the ATOM program that provide information about the ATOM programs' operation:

- AtomLog.txt
- TrendLog.txt
- DCSlog.txt

When used in conjunction with each other the files provide a powerful debugging tool to isolate causes of operation errors.

The log files are located in the "C:\ATOM!\AtomLog\" folder and provide chronological information about the status of the Analyzer, DCS communication as well as analyses results, and can be viewed/edited using Notepad. Each log entry has a date and time stamp, followed by a line of text describing the event. In the event that any of the log files or the AtomLog folder are moved or deleted, the Atom program will re-create a replacement folder and/or the files and will continue logging to the new files (in this event any previously logged data will be lost).

Section 5.1.1 AtomLog.txt

This log provides information about all system alarms and critical events and is basically a snapshot of the "System Settings" screen.   An "x" enclosed in brackets indicates a corresponding check box in the GUI that is checked/selected. Empty brackets indicate that the corresponding box is un-checked/deselected. The logic state of a Digital Input is indicated in parenthesis where (*) indicates the alarm state of a Digital Input. The level of alarm is indicated by the names in parenthesis: (RED) Alarm, (YEL) Warn or (GRN) Normal.

Sample AtomLog.txt file

```
-------------------------------------------------------------------------------
19/05/02  09:17:14  ATOM FGA Event Log Settings SnapShot
-------------------------------------------------------------------------------
19/05/02  09:17:14
19/05/02  09:17:14        Atom Date: 04/18/2019   Version: 7.61
19/05/02  09:17:14         GUI Date: 09/13/2018   Version: 2.0
19/05/02  09:17:14     Detector Date: 04/18/2019   Version: 3.10
19/05/02  09:17:14
-------------------------------------------------------------------------------
19/05/02  09:17:14
19/05/02  09:17:14  Definitions:
19/05/02  09:17:14      where: (*) State = ON, ( ) State = OFF
```

A header is written when a new log file is created detailing the software version, followed by the current status of the System Settings – alarms, status of all check boxes, MFC and TC set points.

19/05/02 09:17:14   where: (GRN) = NORMAL, (YEL) = Warning, (RED) = Alarm
19/05/02 09:17:14   ON OFF   where: [x] = CheckedBox; [ ]= not CheckedBox
19/05/02 09:17:14
19/05/02 09:17:14 -------------------- Starting Atom --------------------
19/05/02 09:17:14
19/05/02 09:17:14   DI-1 Purge Loss OK (GREEN)
19/05/02 09:17:14   DI-2 O² Pressure OK (GREEN)
19/05/02 09:17:14   DI-3 Furnace Temperature ALARM (RED)
19/05/02 09:17:14 [ ]   DI-4 Alarm Check OFF
19/05/02 09:17:14   [ ] DI-4 Warn Check OFF
19/05/02 09:17:14 [ ]   DI-5 Alarm Check OFF
19/05/02 09:17:14   [ ] DI-5 Warn Check OFF
19/05/02 09:17:14 [ ]   DI-6 Alarm Check OFF
19/05/02 09:17:14   [ ] DI-6 Warn Check OFF
19/05/02 09:17:14 [ ]   DI-7 Alarm Check OFF
19/05/02 09:17:14   [ ] DI-7 Warn Check OFF
19/05/02 09:17:14 [ ]   Zero Alarm Check OFF
19/05/02 09:17:14   [ ] Zero Warn Check OFF
19/05/02 09:17:14 [ ]   Span Alarm Check OFF
19/05/02 09:17:14   [ ] Span Warn Check OFF
19/05/02 09:17:14 [ ]   Process Alarm Check OFF
19/05/02 09:17:14   [ ] Process Warn Check OFF
19/05/02 09:17:14 [ ]   MFC1 Alarm Check OFF
19/05/02 09:17:14   [ ] MFC1 Warn Check OFF
19/05/02 09:17:14 [ ]   MFC2 Alarm Check OFF
19/05/02 09:17:14   [ ] MFC2 Warn Check OFF
19/05/02 09:17:14 [ ]   TC1 Alarm Check OFF
19/05/02 09:17:14   [ ] TC1 Warn Check OFF
19/05/02 09:17:14 [ ]   TC2 Alarm Check OFF
19/05/02 09:17:14   [ ] TC2 Warn Check OFF
19/05/02 09:17:14 [ ]   TC3 Alarm Check OFF
19/05/02 09:17:14   [ ] TC3 Warn Check OFF
19/05/02 09:17:14 (GRN) Zero Value   Low = 0.0 Value = 0.0 High = 1,000.0 ppm
19/05/02 09:17:14 (GRN) Span Value   Low = 0.0 Value = 0.0 High = 550,000.0 ppm
19/05/02 09:17:14 (GRN) Process Value   Low = 0.0 Value = 0.0 High = 550,000.0 ppm
19/05/02 09:17:14 19/05/02 09:17:14 (GRN) MFC1 Value   L=0 V=0.0 H=0 (cc/min)
19/05/02 09:17:14 (GRN) MFC2 Value   L=0 V=0.0 H=0 (cc/min)
19/05/02 09:17:14 (GRN) MFC3 Value   L=0 V=0.0 H=0 (cc/min)
19/05/02 09:17:14 (GRN) TC1 Value   L=0.0°C V=0.0°C H=80.0°C
19/05/02 09:17:14 (GRN) TC2 Value   L=1040°C V=0°C H=1060°C
19/05/02 09:17:14 (GRN) TC3 Value   L=0°C V=0.0°C H=40°C
19/05/02 09:17:14 --------------- End of Startup ----------------------
19/05/02 09:17:14
19/05/02 09:17:14
9/05/02 09:17:16 -------- On Start Up --------
19/05/02 09:17:16 RF Counts on Calibration dialog is set to 152,000
19/05/02 09:17:16
19/05/02 09:17:16 Calibration Units on Calibration dialog is set to ppm
19/05/02 09:17:16 Purge time set to 6 secs
19/05/02 09:17:16
19/05/02 09:17:16 Calibration Cycles on Calibration dialog is set to 1
19/05/02 09:17:16 Check Zero on Calibration dialog is set to 0 counts
19/05/02 09:17:16

The digital inputs DI1, DI2 and DI3 are system critical, and the Analyzer will not start analyses unless the status of ALL three DIs is GREEN. In this example, DI3 is RED indicating that the furnace has not reached its set temperature for analysis to begin.
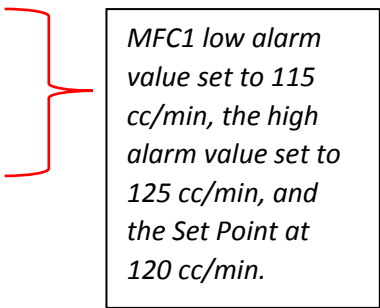
As an example, the Response Factor (RF) was manually changed to 152,000 and the Purge Time was set to 6 seconds.

19/05/02 09:17:16 Zero Average Concentration: 0 ppb
19/05/02 09:17:16
19/05/02 09:17:16 Check Span on Calibration dialog is set to 0 counts
19/05/02 09:17:16
19/05/02 09:17:16 Span Average Concentration: 0 ppb
19/05/02 09:17:16
19/05/02 09:17:16 Zero Conc on Calibration dialog is set to 3.000 ppm
19/05/02 09:17:16 Span Conc on Calibration dialog is set to 2,000.000 ppm
19/05/02 09:17:16 Online Maintenance on Home dialog is is ONLINE
19/05/02 09:17:16 Frequency for Auto Check on Calibration dialog is set to 1 days.
19/05/02 09:17:16
19/05/02 09:17:16 Playback Demo on Calibration dialog is OFF
19/05/02 09:17:16 PMTVolts on Detector dialog is set to 800 volts
19/05/02 09:17:16 Filter on Detector dialog is set to 8 secs
19/05/02 09:17:16 Zero Enabled on Detector dialog is set to OFF
19/05/02 09:17:16 OFFset uV on Detector dialog is set to 0 uV
19/05/02 09:17:16 Hold Time on Detector dialog is set to 0 secs
19/05/02 09:17:16 Cycle Mode on Detector dialog is set to REPEAT
19/05/02 09:17:16 Injection Start on Timed Event dialog is set to 7 secs
19/05/02 09:17:16 Injection Stop on Timed Event dialog is set to 10 secs
19/05/02 09:17:16 SSO/ARV Start on Timed Event dialog is set to 5 secs
19/05/02 09:17:16 SSO/ARV Stop on Timed Event dialog is set to 12 secs
19/05/02 09:17:16 Baseline Start on Timed Event dialog is set to 10 secs
19/05/02 09:17:16 Baseline Stop on Timed Event dialog is set to 19 secs
19/05/02 09:17:16 Auto Zero Time on Timed Event dialog is set to 0 secs
19/05/02 09:17:16 Peak Start on Timed Event dialog is set to 20 secs
19/05/02 09:17:16 Peak Stop on Timed Event dialog is set to 55 secs
19/05/02 09:17:16 Cycle Time on Timed Event dialog is set to 59 secs
19/05/02 09:17:16
19/05/02 09:17:16 Purge Override is set to ON for 10 minutes
19/05/02 09:17:16
19/05/02 09:17:16 Purge Override is set to OFF
19/05/02 09:17:16
19/05/02 09:17:16 TC1 Low set to 0°C
19/05/02 09:17:16
19/05/02 09:17:16 TC1 High set to 80°C
19/05/02 09:17:16
19/05/02 09:17:16 TC1 Set Point set to 70 °C
19/05/02 09:17:16
19/05/02 09:17:16 TC2 Low set to 1040°C
19/05/02 09:17:16
19/05/02 09:17:16 TC2 High set to 1060°C
19/05/02 09:17:16
19/05/02 09:17:16 TC2 Set Point set to 1050 °C
19/05/02 09:17:16
19/05/02 09:17:16 TC2 violations reset to 0
19/05/02 09:17:16
19/05/02 09:17:16 TC3 Low set to 0°C
19/05/02 09:17:16
19/05/02 09:17:16 TC3 High set to 40°C
19/05/02 09:17:16
19/05/02 09:17:16 TC3 Set Point set to 30 °C
19/05/02 09:17:16

> *In addition to the System Settings, the log file records changes made by the user to any of the software menu settings.*
>
> *As seen here, Purge Override is turned ON and set for 10 minutes.*

19/05/02 09:17:16 MFC1 Low set to 0 cc/min
19/05/02 09:17:16
19/05/02 09:17:16 MFC1 High set to 125 cc/min
19/05/02 09:17:16
19/05/02 09:17:16 MFC1 Set Point set to 120 cc/min
19/05/02 09:17:16
19/05/02 09:17:16 MFC2 Low set to 115 cc/min
19/05/02 09:17:16
19/05/02 09:17:16 MFC2 High set to 0 cc/min
19/05/02 09:17:16
19/05/02 09:17:16 MFC2 Set Point set to 0 cc/min
19/05/02 09:17:16
19/05/02 09:17:16 MFC3 Low set to 0 cc/min
19/05/02 09:17:16
19/05/02 09:17:16 MFC3 High set to 0 cc/min
19/05/02 09:17:16
19/05/02 09:17:16 MFC3 Set Point set to 0 cc/min
19/05/02 09:17:16
19/05/02 09:17:16 PMT HV on Home dialog is set to ON
19/05/02 09:17:16
19/05/02 09:17:16 UV Lamp on Home dialog is set to ON
19/05/02 09:17:16
19/05/02 09:17:16 -------- End of Start Up --------
19/05/02 09:17:20
19/05/02 09:17:20 Port opened to DCS
19/05/02 09:17:20
19/05/02 09:17:20 PMT HV on Home dialog is set to ON
19/05/02 09:17:20
19/05/02 09:17:20 UV Lamp on Home dialog is set to ON
19/05/02 09:17:20
19/05/02 09:17:22 RF Counts on Calibration dialog is set to 152,000
19/05/02 09:17:22
19/05/02 09:17:22 Calibration Units on Calibration dialog is set to ppm
19/05/02 09:17:22 Purge time set to 6 secs
19/05/02 09:17:22
19/05/02 09:17:22 Calibration Cycles on Calibration dialog is set to 1
19/05/02 09:17:22 Playback Demo on Calibration dialog is OFF
19/05/02 09:17:23 Frequency for Auto Check on Calibration dialog is set to 1 days.
19/05/02 09:17:23
19/05/02 09:17:23 Zero Conc on Calibration dialog is set to 3.000 ppm
19/05/02 09:17:23 Span Conc on Calibration dialog is set to 2,000.000 ppm
19/05/02 09:17:23 TC2 Set Point set to 1050 °C
19/05/02 09:17:23
19/05/02 09:17:23 TC2 violations reset to 0

> *MFC1 low alarm value set to 115 cc/min, the high alarm value set to 125 cc/min, and the Set Point at 120 cc/min.*

Other events include Check Calibration events as they occur.

16/07/13 09:58:22 Auto Check Time Set: 00:10:00 (DD:HH:MM)
16/07/13 09:59:09 (GRN)   Process Value

16/07/13 10:00:00 Auto Check Event Initiated
16/07/13 10:00:40 Begin Zero Check cycle
16/07/13 10:03:30 End Zero Check Cycle
16/07/13 10:03:30 Begin Span Check cycle
16/07/13 10:06:19 End Span Check Cycle
16/07/13 10:06:19 Begin Validate Check cycle
16/07/13 10:09:09 End Validate Check Cycle
16/07/13 10:15:25 Calculate RF
16/07/13 10:15:28 Save Calibration
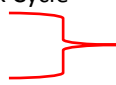
> *Here, the user has clicked on the "Calculate RF" button and then re-calibrated the Analyzer by clicking on "Save Calibration"*

Section 5.1.2 Trend Log

The Trend Log is a comma delimited text file that contains the results of all analyses. It is organized in a format compatible for importing into EXCEL.

Sample TrendLog.txt file

When it begins logging, the TrendLog.txt file prints a header which has a date and time stamp, Run Cycle (count of cycles run since analyzer was last started), Stream Cycle (how many of the pre-set calibration cycles have been completed), and Process and Calibration concentrations.

YY/MM/DD HH:MM:SS	Run Cycle	Stream Cycle	Process (ppm)	Zero (ppm)	Span (ppm)	Validate (ppm)
19/04/26 11:54:26	60		2,301.8			
19/04/26 11:55:27	61		2,294.6			
19/04/26 11:56:27	62		2,323.5			
19/04/26 11:57:27	63		2,323.5			
19/04/26 11:58:27	64		2,318.0			
19/04/26 11:59:27	65		2,303.1			
19/04/26 12:00:27	66		2,289.9			
19/04/26 12:01:27	67		2,301.8			
19/04/26 12:02:27	68		2,294.6			
19/04/26 12:03:27	69		2,315.1			
19/04/26 12:04:27	70		2,323.5			
19/04/26 12:05:27	71		2,318.0			
19/04/26 12:06:27	72		2,303.1			
19/04/26 12:07:28	73		2,289.9			
19/04/26 12:08:28	74		2,301.8			
19/04/26 12:09:28	75		2,294.6			
19/04/26 12:10:28	76	1		180		
19/04/26 12:11:28	77	2		250		
19/04/26 12:12:28	78	3		195		
19/04/26 12:13:28	79	1			2,303.1	
19/04/26 12:14:28	80	2			2,289.9	
19/04/26 12:15:28	81	3			2,301.8	
19/04/26 12:16:28	82	1				2,294.6
19/04/26 12:17:28	83	2				2,315.1
19/04/26 12:18:28	84	3				2,323.5

19/04/26 12:19:29	85	2,318.0
19/04/26 12:20:29	86	2,303.1
19/04/26 12:21:29	87	2,289.9
19/04/26 12:22:29	88	2,301.8
19/04/26 12:23:29	89	2,294.6
19/04/26 12:24:29	90	2,315.1
19/04/26 12:25:29	91	2,323.5
19/04/26 12:26:29	92	2,318.0
19/04/26 12:27:29	93	2,303.1
19/04/26 12:28:29	94	2,289.9
19/04/26 12:29:29	95	2,301.8

Following is an example of the above TrendLog.txt file when exported into Excel.

	A	B	C	D	E	F	G	H
1	YY/MM/DD	HH:MM:SS	Run	Stream	Process	Zero	Span	Validate
2			Cycle	Cycle	(ppm)	(ppm)	(ppm)	(ppm)
3	19/04/26	11:54:26	60		2,301.80			
4	19/04/26	11:55:27	61		2,294.60			
5	19/04/26	11:56:27	62		2,323.50			
6	19/04/26	11:57:27	63		2,323.50			
7	19/04/26	11:58:27	64		2,318.00			
8	19/04/26	11:59:27	65		2,303.10			
9	19/04/26	12:00:27	66		2,289.90			
10	19/04/26	12:01:27	67		2,301.80			
11	19/04/26	12:02:27	68		2,294.60			
12	19/04/26	12:03:27	69		2,315.10			
13	19/04/26	12:04:27	70		2,323.50			
14	19/04/26	12:05:27	71		2,318.00			
15	19/04/26	12:06:27	72		2,303.10			
16	19/04/26	12:07:28	73		2,289.90			
17	19/04/26	12:08:28	74		2,301.80			
18	19/04/26	12:09:28	75		2,294.60			
19	19/04/26	12:10:28	76	1		180		
20	19/04/26	12:11:28	77	2		250		
21	19/04/26	12:12:28	78	3		195		
22	19/04/26	12:13:28	79	1			2,303.10	
23	19/04/26	12:14:28	80	2			2,289.90	
24	19/04/26	12:15:28	81	3			2,301.80	
25	19/04/26	12:16:28	82	1				2,294.60
26	19/04/26	12:17:28	83	2				2,315.10
27	19/04/26	12:18:28	84	3				2,323.50
28	19/04/26	12:19:29	85		2,318.00			
29	19/04/26	12:20:29	86		2,303.10			
30	19/04/26	12:21:29	87		2,289.90			
31	19/04/26	12:22:29	88		2,301.80			
32	19/04/26	12:23:29	89		2,294.60			
33	19/04/26	12:24:29	90		2,315.10			
34	19/04/26	12:25:29	91		2,323.50			
35	19/04/26	12:26:29	92		2,318.00			
36	19/04/26	12:27:29	93		2,303.10			
37	19/04/26	12:28:29	94		2,289.90			
38	19/04/26	12:29:29	95		2,301.80			

Section 5.1.3 DCS Log

The DCSLog.TXT file maintains a running log of all "Control" signals received by the ATOM from the DCS / PLC, i.e. the log records the status of Modbus Control Registers in the range between R00001 and R00064.

When used in conjunction with AtomLog, it helps ascertain whether or not a particular change in status of the Analyzer was requested by the DCS / PLC.

Sample DCSLog.txt file

19/03/30 05:48:12 R20 Stream 2 Enable = ON
19/03/30 05:48:17 R2 Run = ON
19/03/30 05:50:32 R2 Run = OFF
19/03/30 05:51:04 R20 Stream 2 Enable = OFF
19/03/30 05:51:14 R21 Zero Enable = ON
19/03/30 05:51:19 R2 Run = ON
19/03/30 05:53:32 R2 Run = OFF
19/03/30 05:54:04 R21 Zero Enable = OFF
19/03/30 05:54:14 R19 Stream 1 Enable = ON
19/03/30 05:54:19 R2 Run = ON
19/03/30 05:56:32 R2 Run = OFF
19/03/30 05:57:04 R19 Stream 1 Enable = OFF
19/03/30 05:57:14 R20 Stream 2 Enable = ON
19/03/30 05:57:19 R2 Run = ON
19/03/30 05:59:33 R2 Run = OFF
19/03/30 06:00:05 R20 Stream 2 Enable = OFF
19/03/30 06:00:15 R21 Zero Enable = ON
19/03/30 06:00:20 R2 Run = ON
19/03/30 06:02:35 R2 Run = OFF
19/03/30 06:03:05 R21 Zero Enable = OFF
19/03/30 06:03:15 R19 Stream 1 Enable = ON
19/03/30 06:03:20 R2 Run = ON
19/03/30 06:05:33 R2 Run = OFF
19/03/30 06:06:05 R19 Stream 1 Enable = OFF
19/03/30 06:06:15 R20 Stream 2 Enable = ON
19/03/30 06:06:20 R2 Run = ON
19/03/30 06:08:33 R2 Run = OFF
19/03/30 06:09:05 R20 Stream 2 Enable = OFF
19/03/30 06:09:16 R21 Zero Enable = ON
19/03/30 06:09:20 R2 Run = ON
19/03/30 06:11:34 R2 Run = OFF
19/03/30 06:12:06 R21 Zero Enable = OFF
19/03/30 06:12:16 R19 Stream 1 Enable = ON
19/03/30 06:12:21 R2 Run = ON

This sample log is taken from an Analyzer that is totally controlled by a PLC. As seen in this sample log, the PLC stops the analysis at the end of every cycle (R00002 = OFF), actuates one of registers R00019, R00020 or R00021 (selects stream to run), and then re-starts the analysis (R00002 = ON).

Section 5.2 ATOM2 features

The ATOM2 comes with certain features that are not accessible through the GUI. Among the main ones, they provide the user with extended and user-selectable data logging, fully accessible Modbus map to verify DCS data validity, and ability to program MFC addresses.

Section 5.2.1 Accessing the ATOM2 menus - Login

⚡ *Caution*:   Accessing these menus gives user the ability, to change Temperature and Mass Flow Controller settings (among others). Any un-authorized changes to these settings could result in erroneous results and/or damage to the Analyzer.

In order to access all the ATOM2 features, the user will need to login using a password that is independent of the GUI. (Please check with your supervisor for login privileges.)

On the ATOM program, click on "Login" as shown below in *Figure 7.1*. Enter the login password using the On-Screen Keyboard, and click OK.
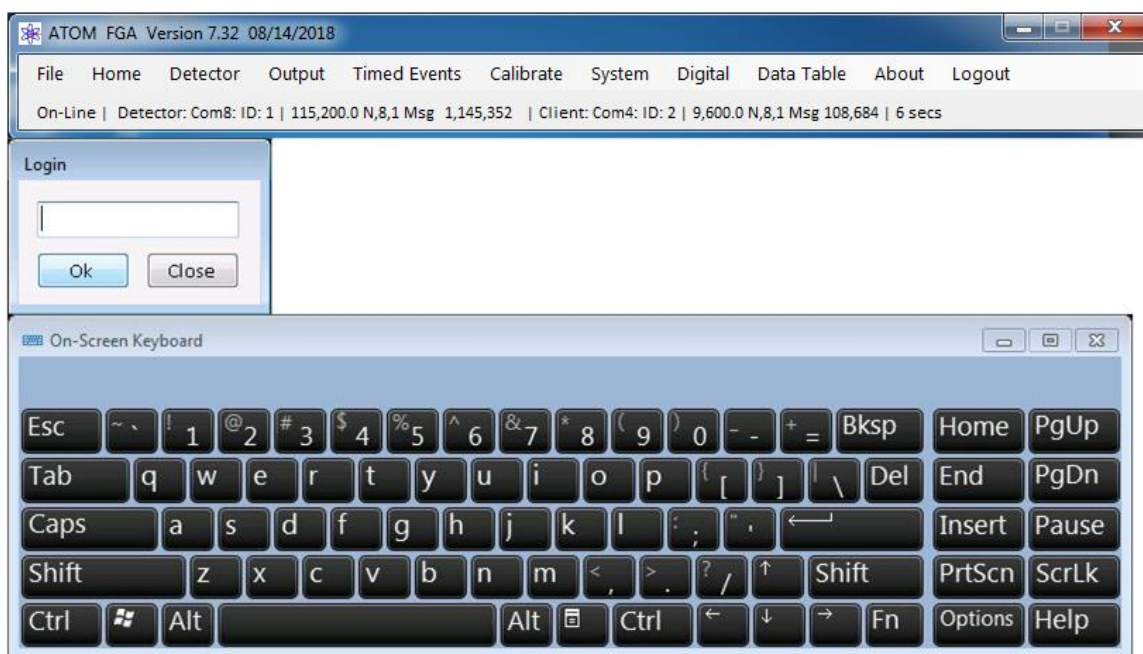
Figure 7.1 – ATOM Login

Once login is successful user will be able to make changes to Analyzer menus.

Section 5.2.2 Accessing the Modbus Map

On the ATOM program, click on "File" and "Show Registers" as shown below in *Figure 7.2*.
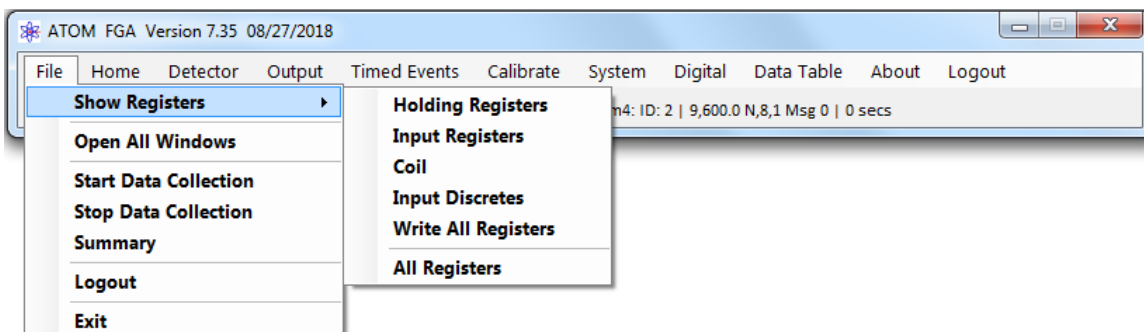
Figure 7.2 – ATOM – Modbus Registers

By individually selecting the Holding, Input, Coil, or Input Discrete registers will bring up the entire table of the corresponding Modbus registers with the updated current value in unsigned integer format.

Selecting "All Registers" will simultaneously bring up all 4 Modbus tables (Figure).
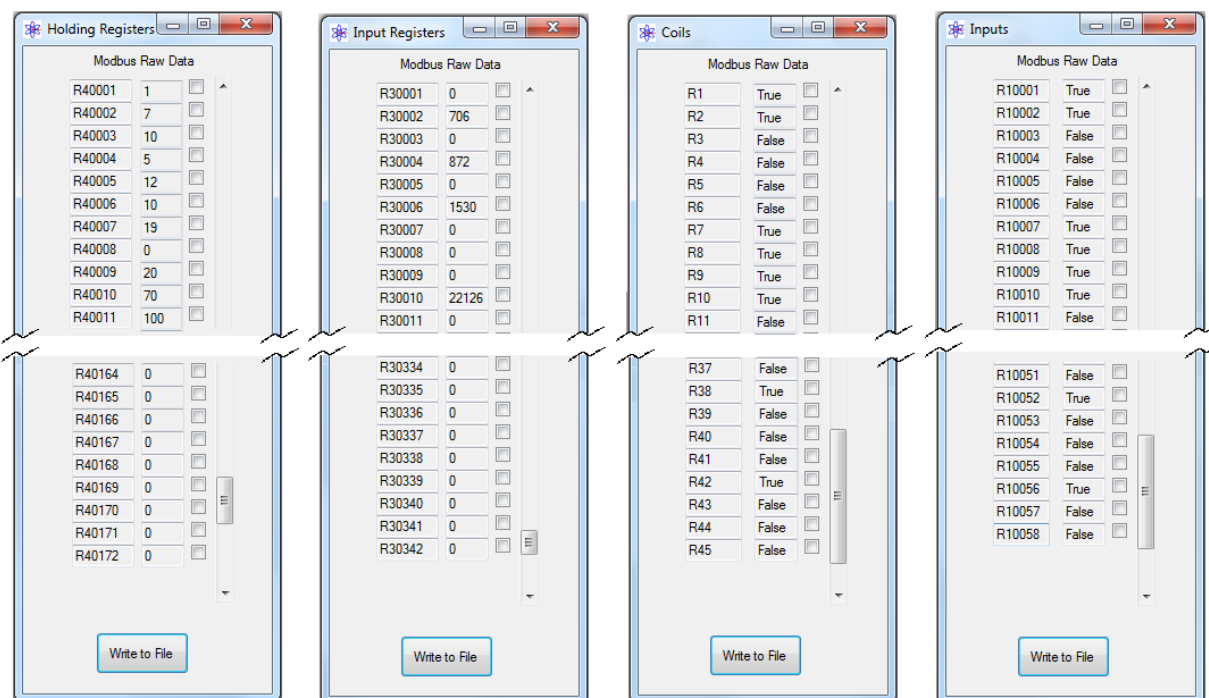
Interpreting the Modbus Data

The Modbus data for Holding and Input Registers is either stored in a single 16-bit register or in a 16-bit register pair.
The data in the single 16-bit register is read as-is. To interpret the data in the register pair, apply the following math to the two registers:

(Higher order 16-bit register X 65536) + (Lower order 16-bit register)

For example, in the register pair R30001-02, R30001 is the higher order 16-bit register, and R30002 is the Lower order 16-bit register.

The Input and Coil registers are single bit registers and can only have one of two states: True=1, False=0.

Section 5.2.3 Open All Windows

Clicking on "File" and "Open All Windows" will pull up and cascade all menus (*Figure 7.3*).
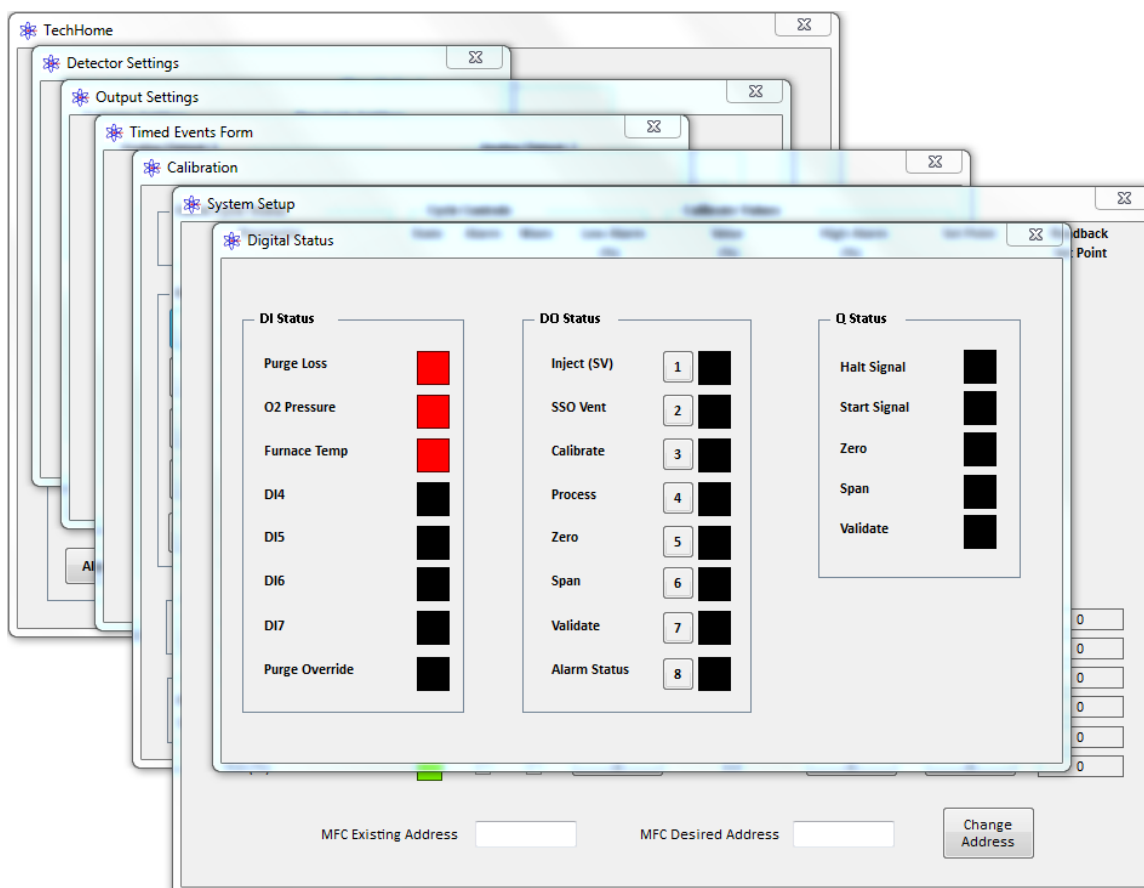
Figure 7.3 – ATOM – Open all windows

Section 5.2.4 Extended Data Logging

On the ATOM program, clicking on "File", and then "Start Data Collection" opens a dialog window.
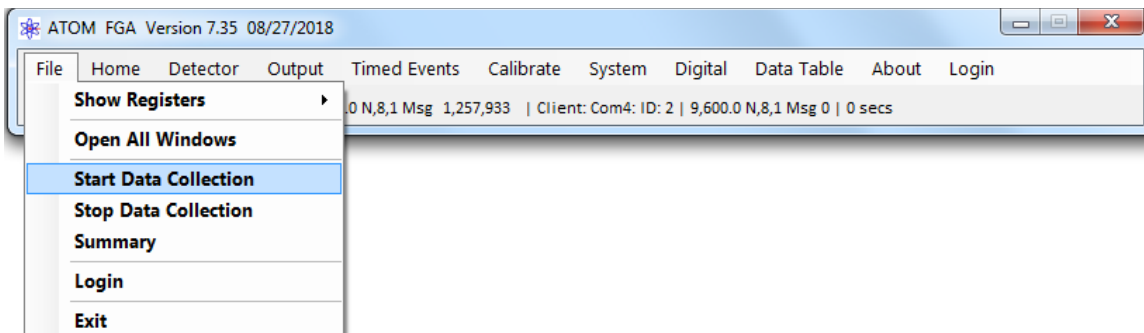
Figure 7.4 – Start Data Collection

This window lets user select parameters to log (*Figure 7.1 – ATOM Login*).
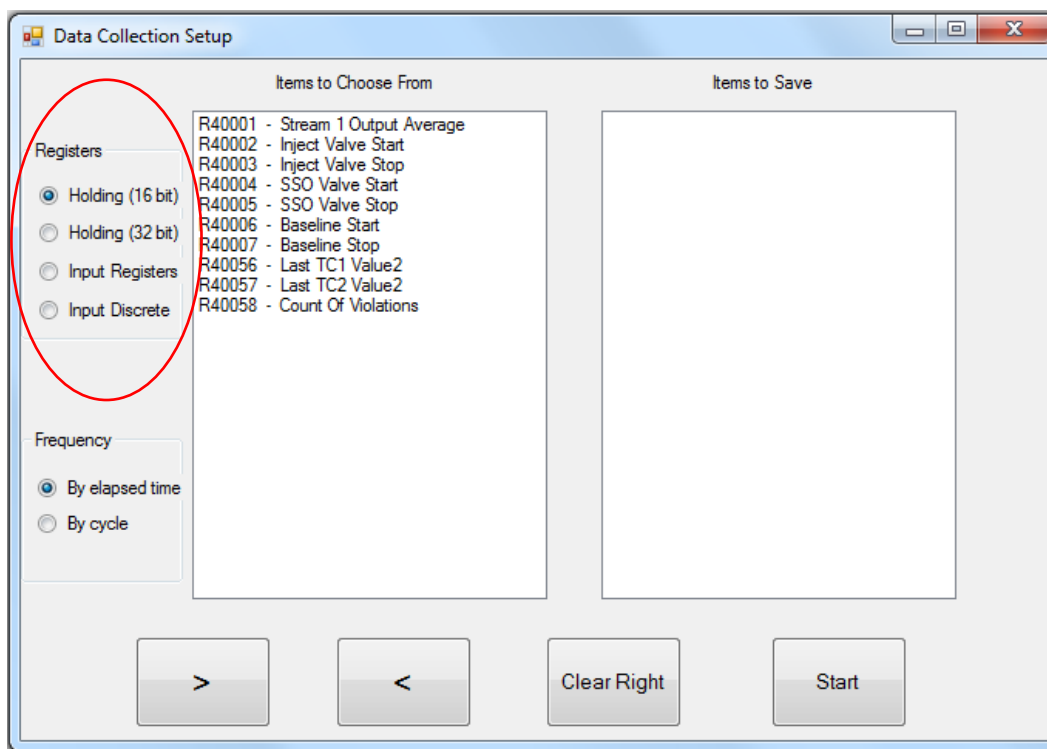
Figure 7.5 – Data Collection parameters

From the list of Registers in the left side pane, select the parameters you wish to log. Then click on the ">" button to transfer the parameter to the "Items to Save" pane on the right. When you are done with the selections, click "Start". This will start data logging to the "DataCollection.txt" file located at C:\ATOM!\ directory. The data can be set to log every

second (By elapsed time), or at the end of every cycle (By cycle). This selection applies to ALL selected parameters, and cannot be set for individual parameters.

Clicking "Clear Right" will clear all current selections and you can start over.

The data logging can be stopped by clicking on "File" and then "Stop Data Collection" on the ATOM program.

Section 5.2.5 Replacing a MFC and programming the correct address

Depending upon the application, the online Analyzer may consist of up to 3 MFCs. This option enables users to install a new MFC and program it to the required address with a single click of a button (*Note*: this option will only work if the default MFC address = 0).

Install the new MFC, connect the communication cable to the **single MFC** whose address needs to be programmed. **Disconnect** all other MFCs, if present. On the ATOM program, click on "File" and "Set MFC Address" as shown below in *Figure 7.6*.
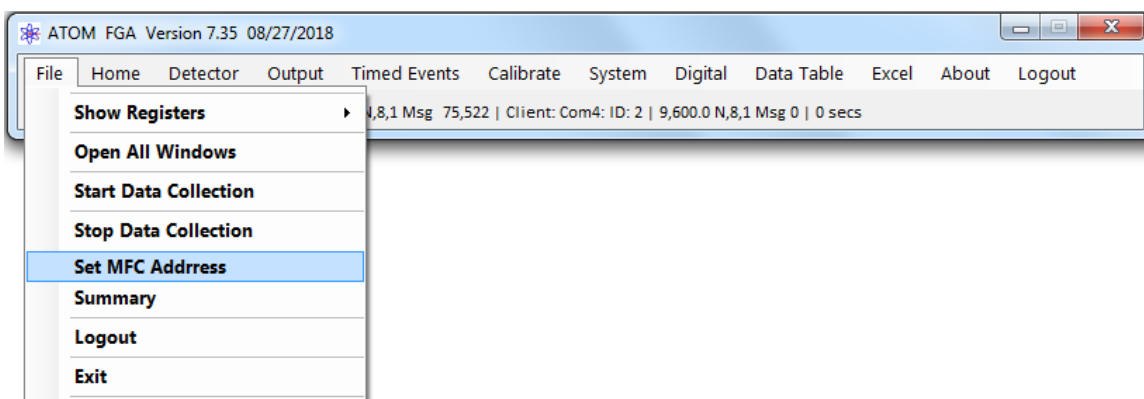
Figure 7.6 – Set MFC Address

For example, if MFC1 has been replaced, in the dialog box click on "Set MFC1 Address". The ATOM program will automatically set the MFC1 address to 11. A "✔" indicates that programming was complete. Click on the ☒ to close the dialog box (*Figure 7.7*).

Note: *For applications that also contain MFC2 and/or MFC3, their respective addresses will be automatically programmed to 12 and 13.*
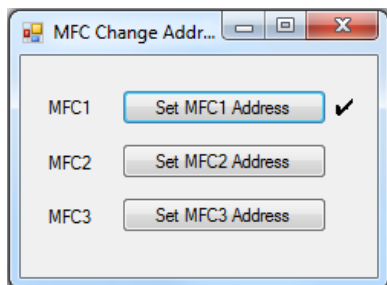
Figure 7.7 – Set MFC address

Section 5.2.6 Changing MFC addresses

In addition to programming addresses for new MFCs, it is also possible to re-program a MFC address provided that its' current address is known.

This utility can be accessed in the ATOM program's System Setup window.

To begin, if multiple MFCs are installed, disconnect all MFC communication cables except to the MFC whose address needs to be changed (*Figure 7.8*).
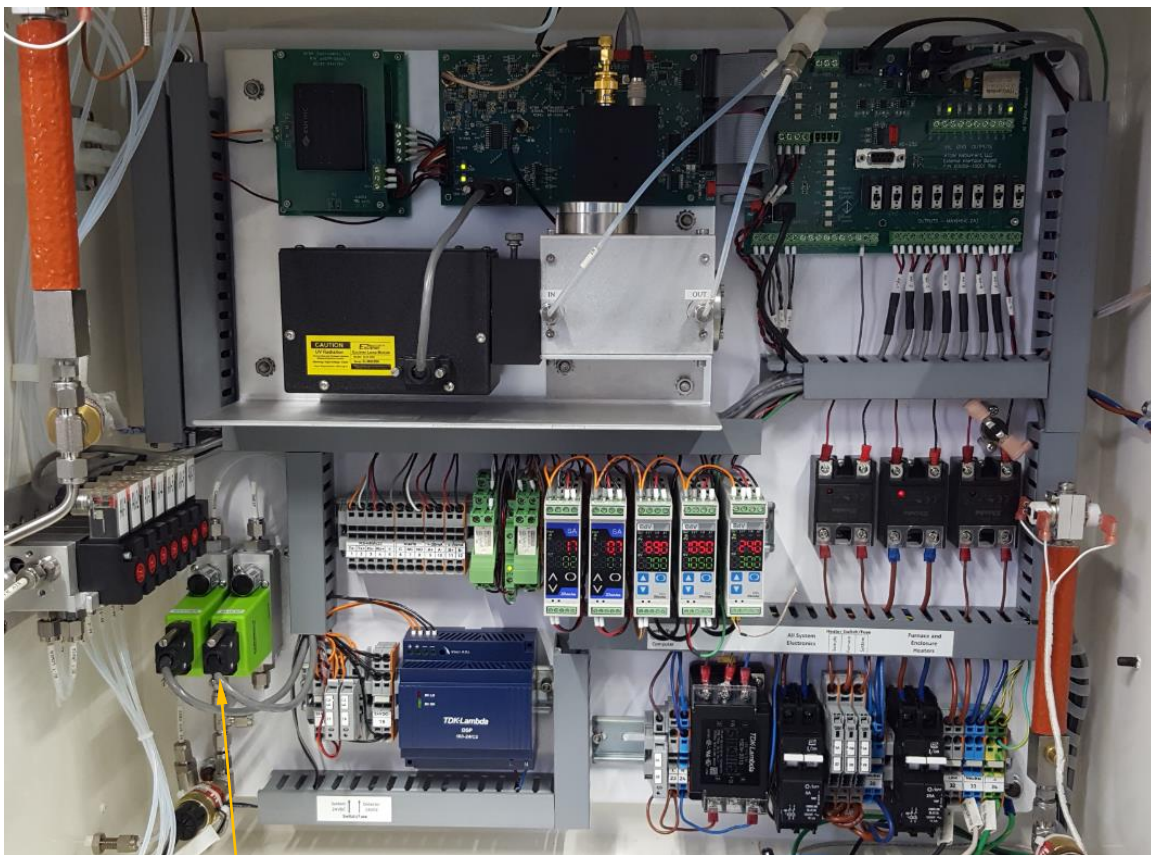
Figure 7.7 – MFC connections

MFC communication cable

On the ATOM program, click on "System", and the System Setup window will open as shown below in *Figure 7.9*.

Figure 7.9 – Change MFC address

In the "MFC Existing Address" textbox, enter "0" (or the current address of the MFC). In the "MFC Desired Address" textbox enter the desired MFC address – typically 11, 12, or 13. Click on "Change Address". The MFC will now be programmed to the new address. Re-connect all the MFC communication cables to resume normal Analyzer operation.

Section 5.2.7 Changing the MFC and TC Set Points

On the ATOM program, click on "System", and the System Setup window will open as shown below in *Figure 7.10*.
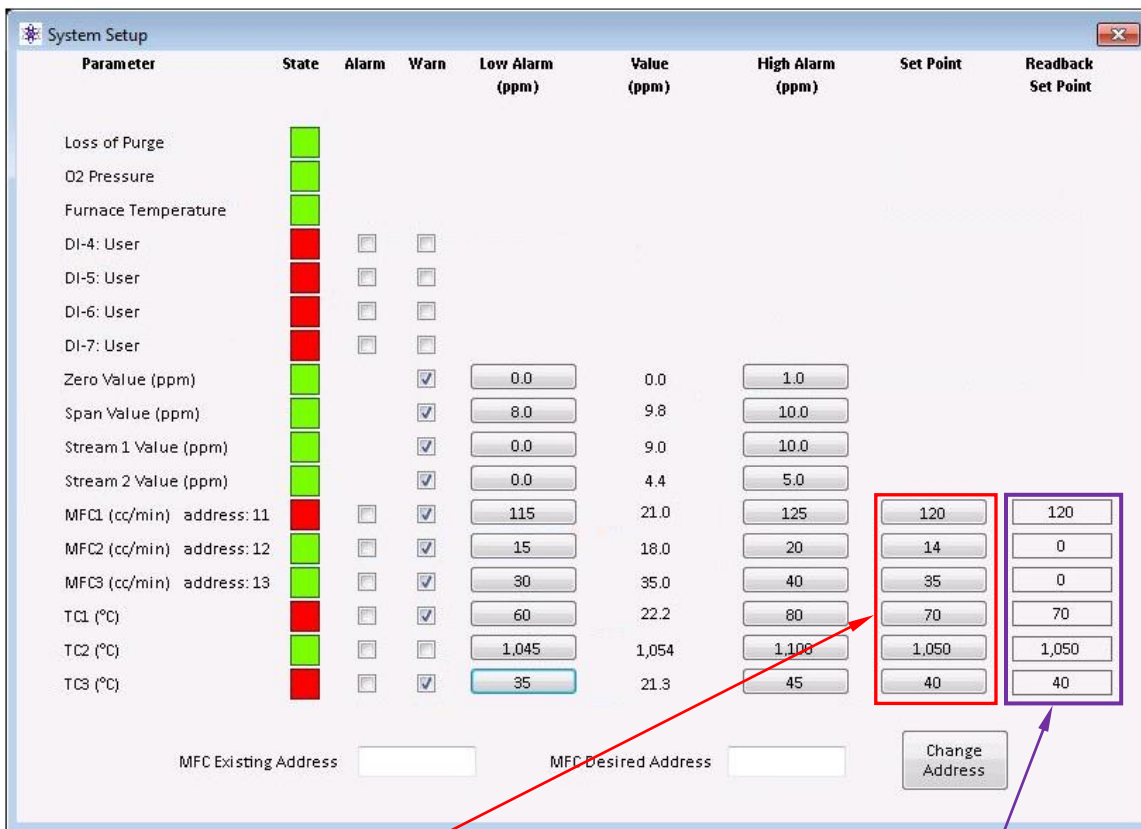
Figure 7.10 – MFC and TC Set points

Click on the device's button whose set point you wish to change. In the dialog box that opens enter the new Set point and click OK (*Figure 7.11*). Once the new set point is accepted by the device (MFC or TC), the new set point is read back by the ATOM and displayed in the "Readback Set Point" text box.

Figure 7.11 – Enter new set point

Section 5.2.8 Data Display

On the ATOM program, click on "Data Table" as shown below in Figure .
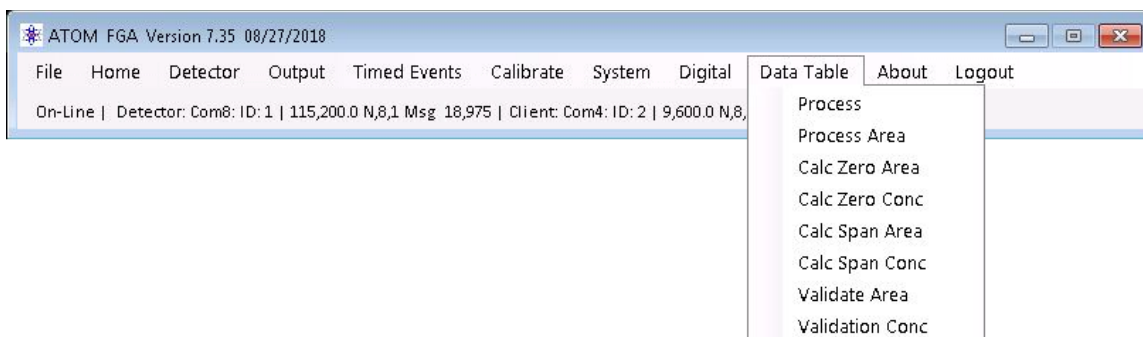
Figure 7.12 – Data tables

The drop-down menu to select the process or calibration results as shown below in *Figures 7.13, 7.14*.

Process data tables:
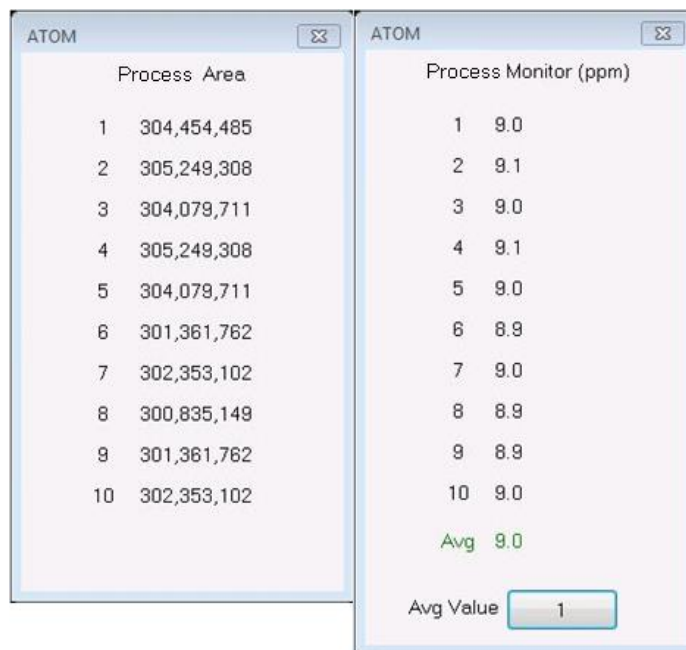
Figure 7.13 – Process data

Calibration data tables:

ATOM	☒
Calculate Zero Area	
1	433,441
2	457,969
3	439,516
4	477,067
5	433,441
6	0
7	0
8	0
9	0
10	0
Avg	448,286

ATOM	☒
Calculate Span Area	
1	302,349,282
2	301,357,942
3	304,075,891
4	305,245,488
5	304,450,665
6	0
7	0
8	0
9	0
10	0
Avg	303,495,853

ATOM	☒
Validate Area	
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
Avg	0

ATOM	☒
Calculate Zero Conc (ppm)	
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0
6	0.0
7	0.0
8	0.0
9	0.0
10	0.0
Avg	0.0

ATOM	☒
Calculate Span Conc (ppm)	
1	9.8
2	9.7
3	9.8
4	9.9
5	9.8
6	0.0
7	0.0
8	0.0
9	0.0
10	0.0
Avg	9.8

ATOM	☒
Validate Conc (ppm)	
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0
6	0.0
7	0.0
8	0.0
9	0.0
10	0.0
Avg	0.0

Figure 7.14 – Calibration data

Section 6 – Postscript

Section 6.1 Procedure To Auto-Tune Temperature Controller

Whenever the thermocouple is replaced, the Temperature Controller needs to be "Auto-Tuned" for optimal performance. This is an automatic procedure which sets the PID control parameters that the Temperature Controller uses to maintain the "set" temperature value.

Before beginning the Auto-Tuning procedure:

- Install the new thermocouple (verify that the polarity is correct)
- For proper Auto-Tuning, the furnace temperature must be cooled to less than 90% of the set point value (for a Set Point of 1050°C, less than 940 °C)
- Verify that the Furnace breaker is switched ON
- Verify that the Analyzer is in "Purge Override" (otherwise power to the furnace will remain disabled)

Begin:

Press the ⬭ key while holding down the ◿ key and the Temperature Controller reads "AT" and the first line and "----" on the second line.

Press the ◿ key and both the top and bottom line on the Temperature Controller will read "AT".

Press the ⬭ key to start the "Auto-Tune" procedure. The **"AT"** indicator will begin to flash ON and OFF, and the furnace temperature will begin to increase indicating that the Auto-Tune procedure is in progress.

Once the procedure is complete, the "AT" indicator will automatically turn OFF, and the optimized PID values should maintain the furnace at its set temperature.

***Note :*   **During the Auto-tuning procedure it is normal for the furnace temperature to briefly over-shoot the set temperature value.**

Section 6.2 Calibration/Validation Procedure

The Calibrate settings screen *(Figure 8.1)* contains all the information regarding instrument calibration and associated calibration results.

To access this screen press **Settings > Calibrate Settings**

Figure 8.1 – Calibrate Settings Screen

Settings
1. **Cycles/set** ①: Set this at 5.
2. **Purge (Sec)** ②: Set this at ≥ 60 (minimum recommended purge time).
3. **Zero Conc** ③: Set this to the SO2 concentration in the Zero cal standard.
4. **Span Conc** ④: Set this to the SO2 concentration in the Span cal standard.
5. **Span Conc** ⑤: Select unit based on the format of the value entered in the cal standard.

Procedure
1. Select **Run Zero** ⑦. After 5 cycles of Zero are completed, the value in **Check Zero** ⑨ will get updated.
2. Select **Run Span** ⑧. After 5 cycles of Span are completed, the value in **Check Span** ⑩ will get updated.

3. Select **Calculate RF** ⑪. Wait for the value to get updated in **RF=Count/ppm** ⑥.
4. Select **Save Calibration** ⑫ after the indicator on this button turns green.
5. Values in **Saved Zero** ⑭ and **Saved Span** ⑮ will get updated and will be same as ⑨ & ⑩.
6. Select **View Results** ⑰. **Check Calibration Results** screen will open *(Figure 8.2).*

Run	Zero		Span	
	Area	Conc %	Area	Conc %
1	0	0.00	309,236,128	50.36
2	0	0.00	308,633,134	50.26
3	0	0.00	306,712,151	49.95
4	0	0.00	304,737,106	49.63
5	0	0.00	306,421,694	49.90
6				
7				
8				
9				
10				
Average	0	0.00	307,148,042	50.02

Figure 8.2 – Check Calibration Results Screen

Manual Validation:

Settings
1. Keep all the settings same as in Manual calibration.

Procedure
1. Select **Run Validate** ⑯.
2. The "average" result of all the validation cycles run and the date and time of Validation will be displayed in the "Last Validation" window ⑱.

Field Certification
Certificate of Compliance

Certificate: 2744021

Project: 2744021 **Date Issued:** 2014-08-29

Issued to: **ATOM Instrument, LLC.**
1656 Townhurst Dr.
Houston, TX. 77043
USA
Attention: Franek Oltowski

The products listed below are eligible to bear CSA Field Certification Labels, bearing the CSA Mark shown with adjacent indicators 'C' and 'US'.

Issued by: Tony DeSousa CET

PRODUCTS
CLASS – 2258 02 – PROCESS CONTROL EQUIPMENT - For Hazardous Locations
CLASS – 2258 82 – PROCESS CONTROL EQUIPMENT - For Hazardous Locations - US requirements.

Class I Division 2 Groups B, C and D. T3, Purge type "Z".

Model ATOM FGA-1000 rated; 120 Vac@25.0 Amps, 60 Hz.

CSA Field Certification Label(s) issued: <u>FC 249403</u> to <u>FC 249407</u>.

APPLICABLE REQUIREMENTS

CSA Standard C22.2 No 0-10   - General Requirements - Canadian Electrical Code, Part II
CSA Standard C22.2 No 0.4-04   - Bonding of Electrical Equipment
CSA Standard C22.2 No 142-M1987 - Process Control Equipment

Certificate: 2744021

LTR 10E-2005 - Purged and Pressurized equipment for use in Class I Hazardous
Locations – North American (Division System) Purging based on NFPA- 496
UL 508 17th Ed. - Electric Industrial Control Equipment.
NFPA 496:2013 - Purged and Pressurized Electrical Equipment.

MARKINGS

Y Submittor's name. Y
Model designation. Y
Electrical ratings. Y
Serial number.
Y Hazardous Location designation
Y Temperature code
Y Purge type
Y The following statement:

"WARNING: EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR
SUITABILITY FOR CASS I, DIVISION. 2. Or equivalent

Y WARNING; Enclosure shall not be opened unless the area is known to be Non-hazardous, or
unless all devices within the enclosure have been de-energised. Power must not be
restored after enclosure has been opened until enclosure has been purged for 10 Minutes at 30 PSIG Note;
Read all labels before operating this purged system.

Y "Type Z Purge System."

Y "WARNING; Hot internal components, wait 3 hours prior opening enclosure prior to work." Or equivalent.

DQD 507.07 Rev. 2010-04-22